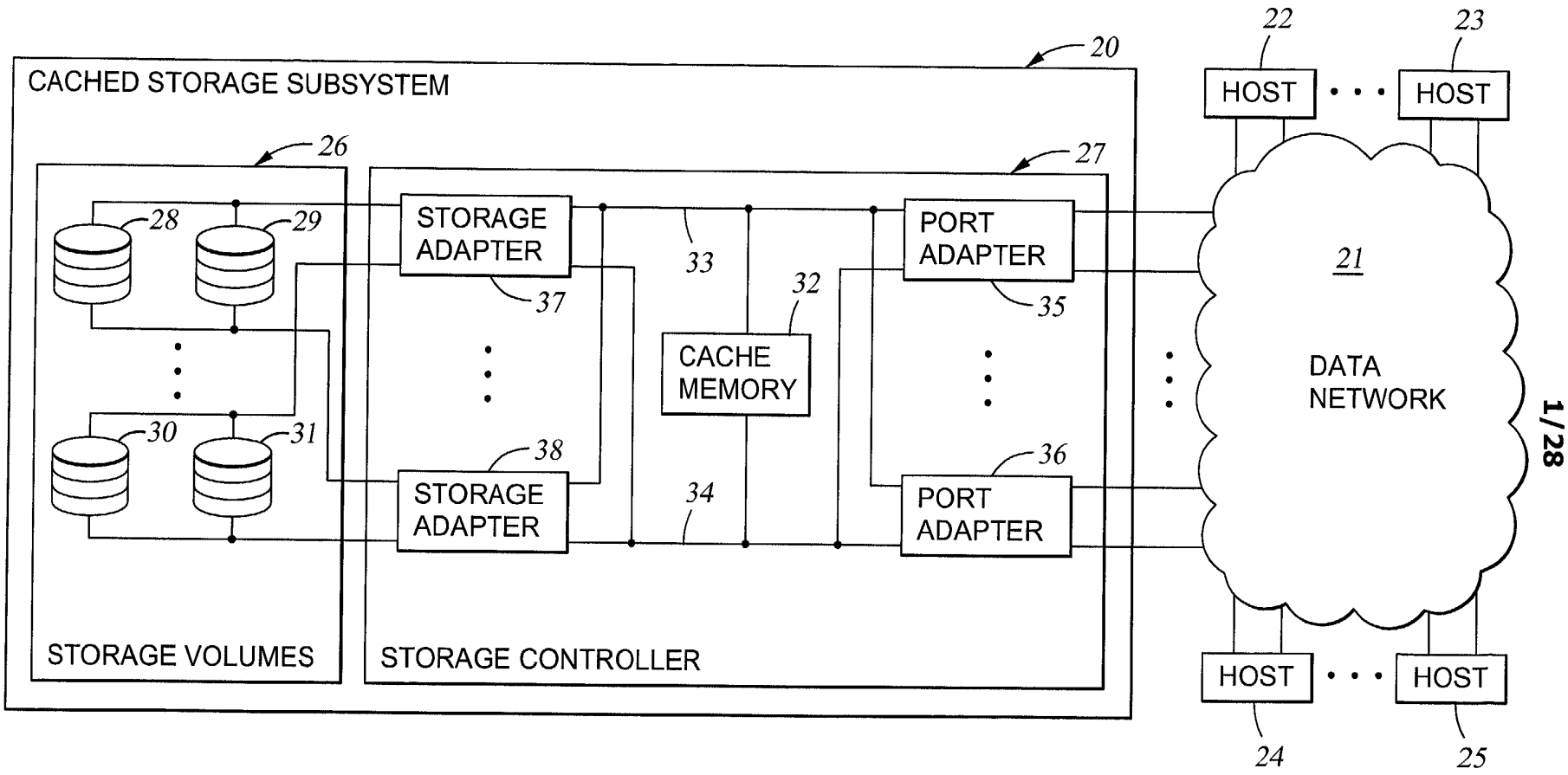
CACHED STORAGE SUBSYSTEM
20
22
23
HOST
HOST
26
27
28
29
STORAGE ADAPTER
37
33
32
CACHE MEMORY
PORT ADAPTER
35
21
DATA NETWORK
30
31
38
STORAGE ADAPTER
34
36
PORT ADAPTER
STORAGE VOLUMES
STORAGE CONTROLLER
HOST
HOST
24
25

*Fig. 1*

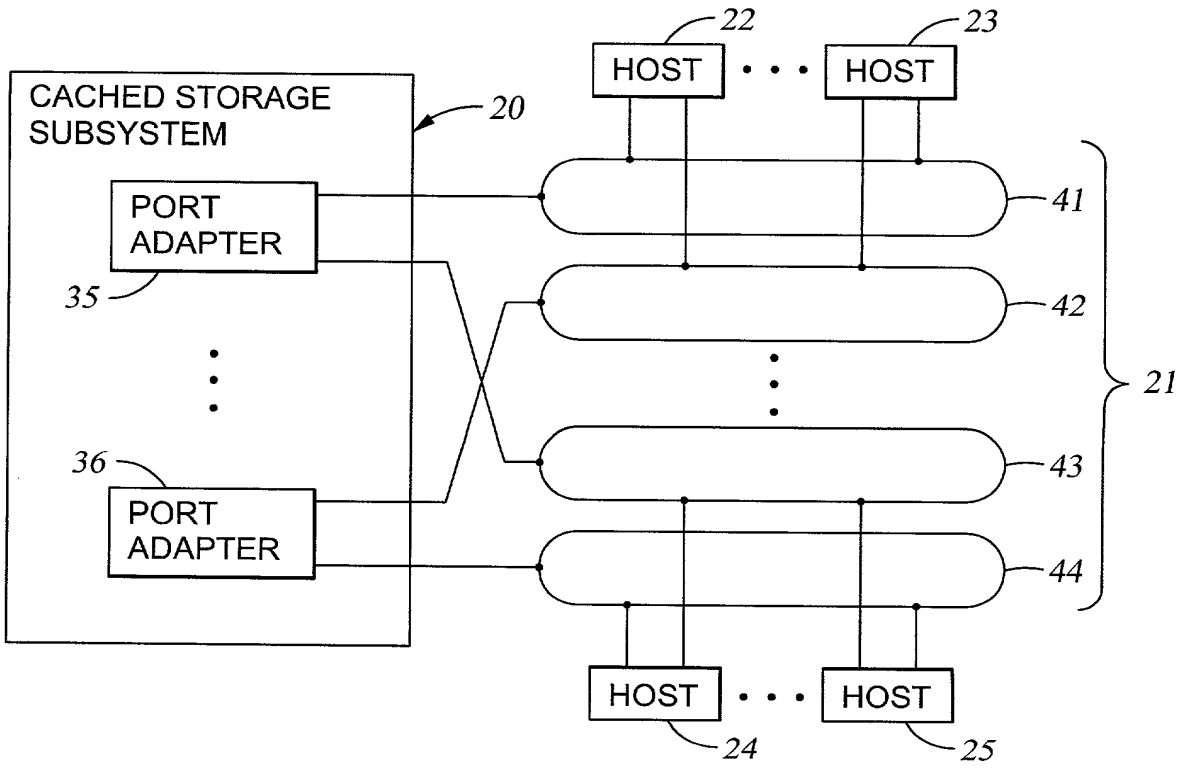
CACHED STORAGE SUBSYSTEM
20
PORT ADAPTER
35
PORT ADAPTER
36
HOST
22
HOST
23
HOST
24
HOST
25
41
42
43
44
21

Fig. 2

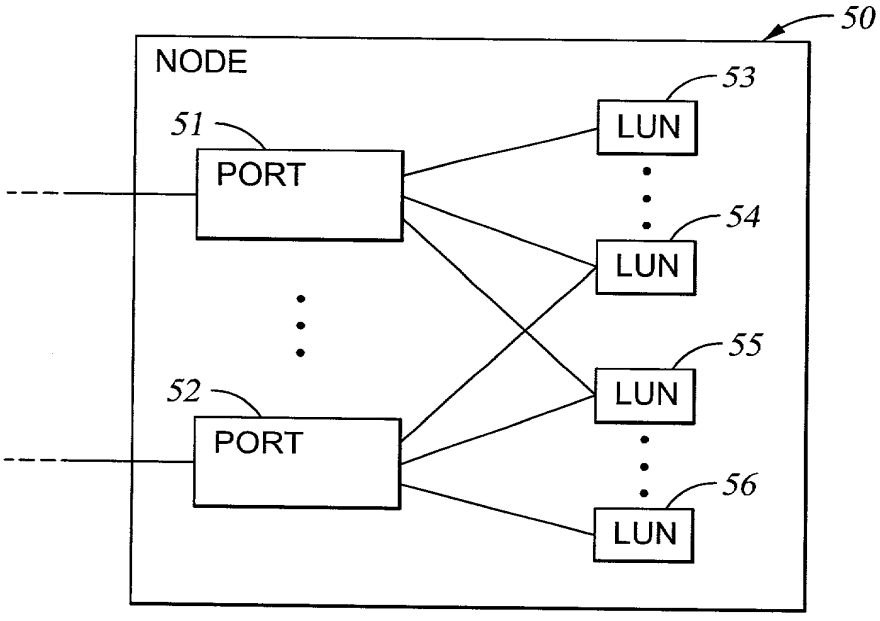
NODE
50
PORT
51
PORT
52
LUN
53
LUN
54
LUN
55
LUN
56

Fig. 3

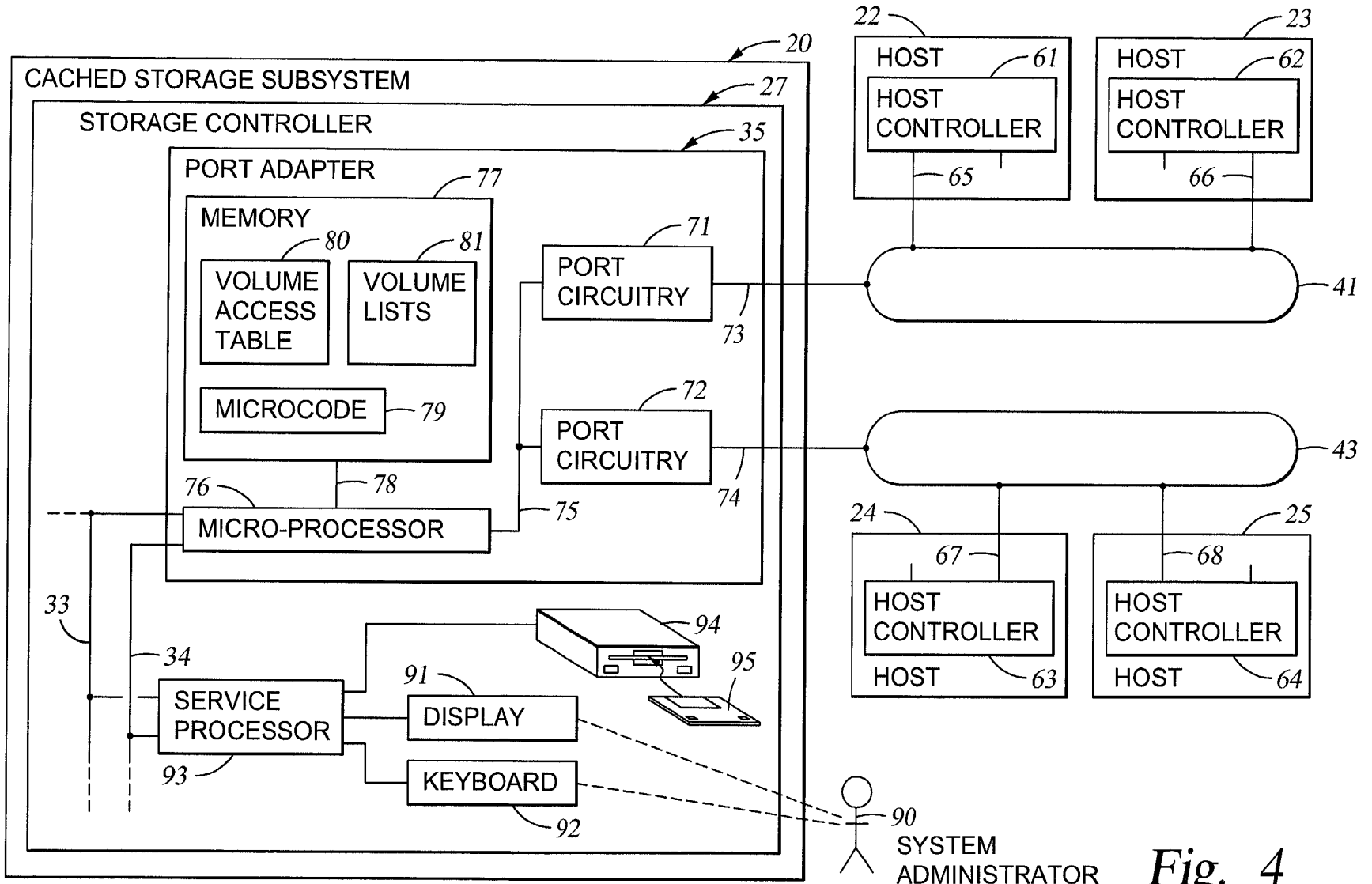
CACHED STORAGE SUBSYSTEM
20
STORAGE CONTROLLER
27
PORT ADAPTER
35
MEMORY
77
VOLUME ACCESS TABLE
80
VOLUME LISTS
81
MICROCODE
79
MICRO-PROCESSOR
76
78
75
PORT CIRCUITRY
71
73
PORT CIRCUITRY
72
74
HOST
22
HOST CONTROLLER
61
65
HOST
23
HOST CONTROLLER
62
66
41
43
HOST
24
HOST CONTROLLER
67
63
HOST
25
HOST CONTROLLER
68
64
33
34
SERVICE PROCESSOR
93
DISPLAY
91
KEYBOARD
92
94
95
90
SYSTEM ADMINISTRATOR

Fig. 4

82

| VOLUME GROUP NAME | HOST CONTROLLER WWN | HOST CONTROLLER S_ID | PRIVATE /SHARED FLAG | VOLUME LIST POINTER |
|---|---|---|---|---|
| HOST 22-1 | 0276ADF1 | 0000B8 | 1 | 0472 |
| HOST 23-2 | 0276ADC2 | 0000B9 | 0 | 0476 |
| HOST 24-2 | 0276AE32 | 0001A7 | 0 | 048E |
| HOST 25-1 | 0276AE51 | 0001A6 | 1 | 04AO |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |

*Fig. 5*

83

| | |
|---|---|
| BEGINNING VOLUME No. | 84 |
| ENDING VOLUME No. | 85 |
| STRIDE-1 | 86 |

*Fig. 6*

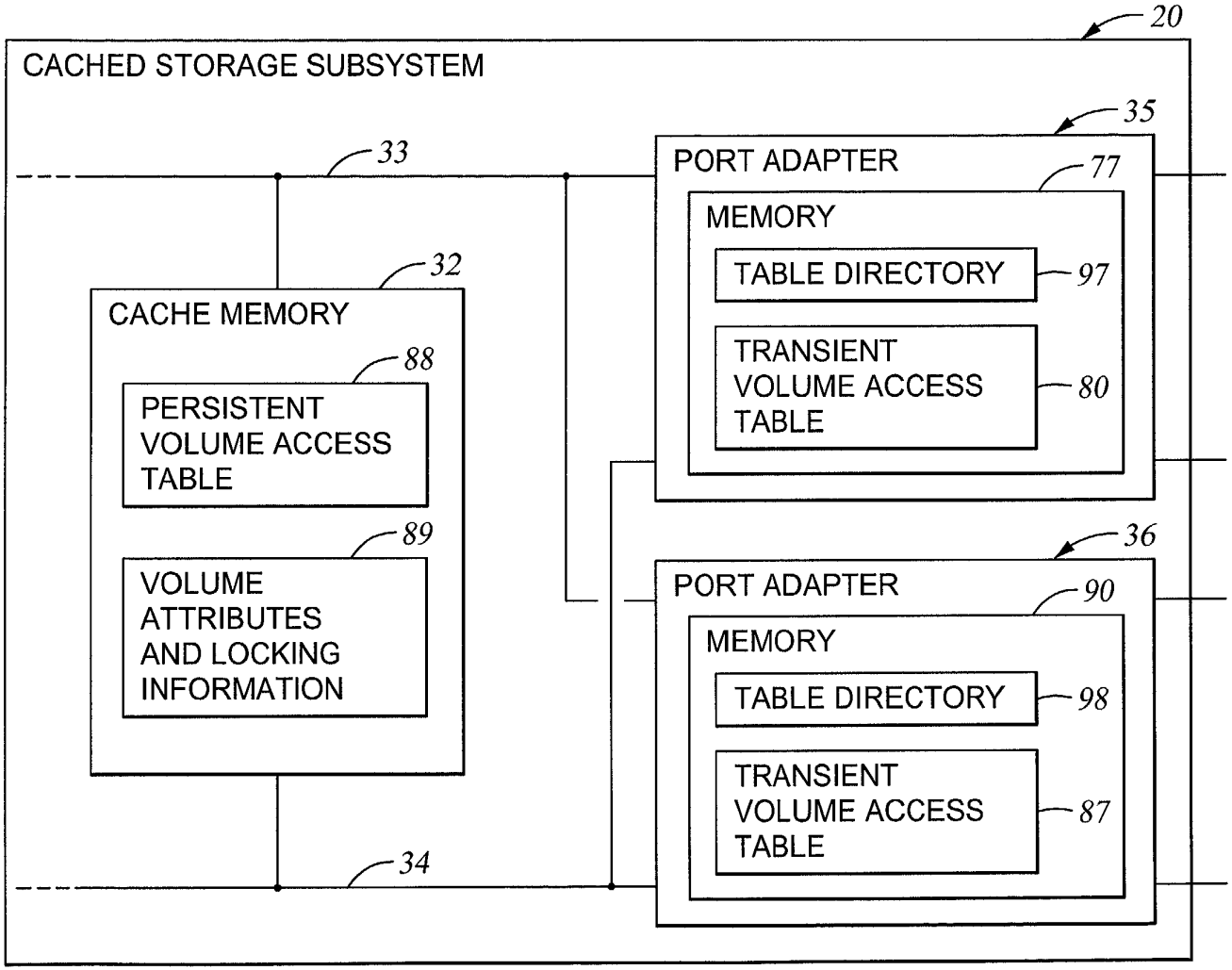
20
CACHED STORAGE SUBSYSTEM
35
33
PORT ADAPTER
77
MEMORY
TABLE DIRECTORY
97
TRANSIENT VOLUME ACCESS TABLE
80
32
CACHE MEMORY
88
PERSISTENT VOLUME ACCESS TABLE
89
VOLUME ATTRIBUTES AND LOCKING INFORMATION
36
PORT ADAPTER
90
MEMORY
TABLE DIRECTORY
98
TRANSIENT VOLUME ACCESS TABLE
87
34

*Fig. 7*

Fig. 8

| VOLUME GROUP NAME | HOST CONTROLLER WWN | PRIVATE /SHARED FLAG | VOLUME BITMAP | VOLUME LIST | PORT ADAPTER INDEX LIST |
|---|---|---|---|---|---|
| – | – | – | – | – | – |
| – | – | – | – | – | – |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |

88

Fig. 9

| HOST CONTROLLER S_ID | PRIVATE /SHARED FLAG | VOLUME BITMAP | PERSISTENT TABLE INDEX |
|---|---|---|---|
| – | – | – | – |
| – | – | – | – |
| ⋮ | ⋮ | ⋮ | ⋮ |

80

Fig. 10

| SID MODULUS | LISTS OF S_IDs AND TRANSIENT TABLE INDICES |
|---|---|
| 0 | (S_ID, INDEX) , (S_ID, INDEX ) , ... |
| 1 | (S_ID, INDEX) , (S_ID, INDEX ) , ... |
| ⋮ | ⋮ |

97

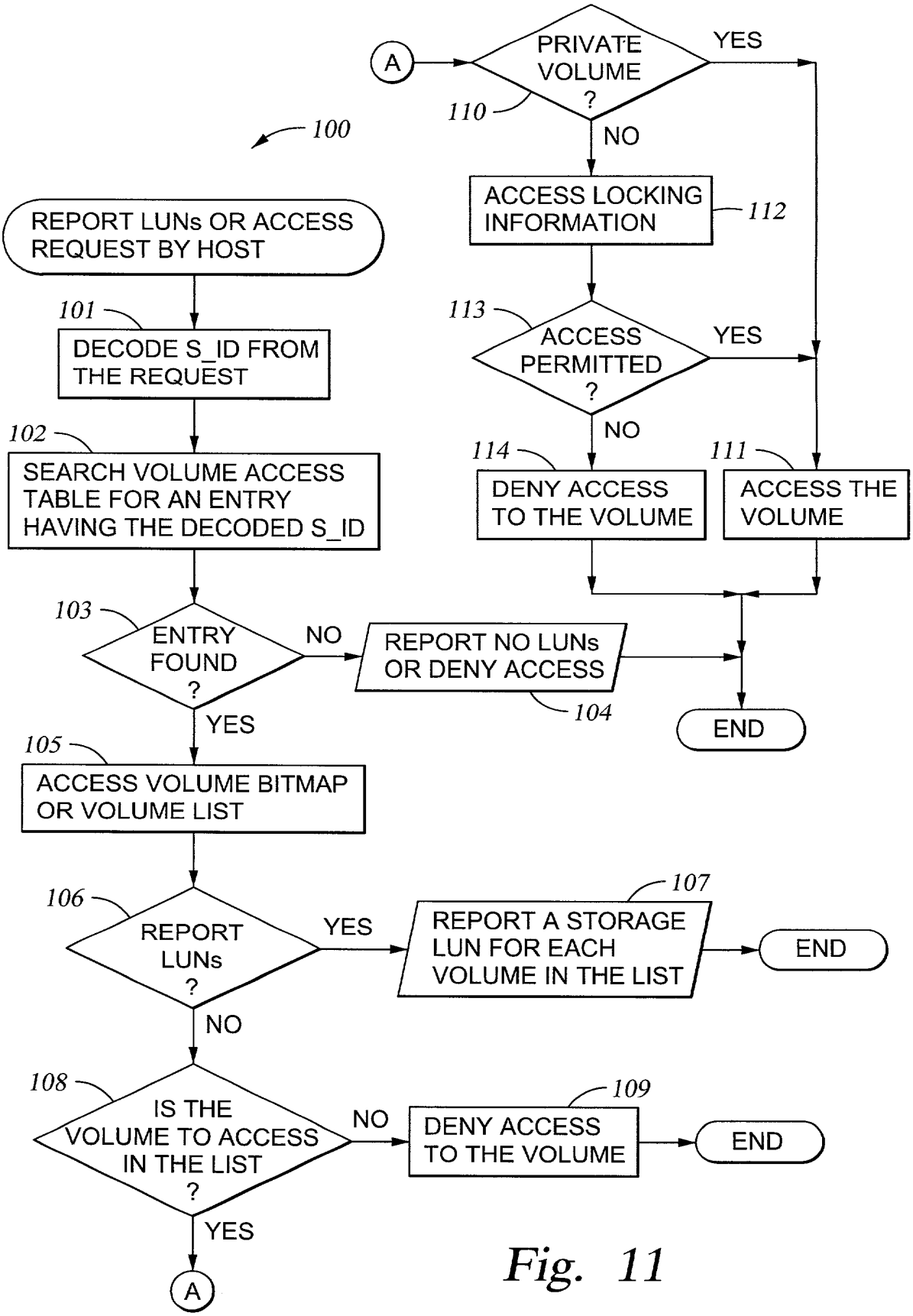
100
REPORT LUNs OR ACCESS REQUEST BY HOST
101
DECODE S_ID FROM THE REQUEST
102
SEARCH VOLUME ACCESS TABLE FOR AN ENTRY HAVING THE DECODED S_ID
103
ENTRY FOUND ?
NO
REPORT NO LUNs OR DENY ACCESS
104
END
YES
105
ACCESS VOLUME BITMAP OR VOLUME LIST
106
REPORT LUNs ?
YES
107
REPORT A STORAGE LUN FOR EACH VOLUME IN THE LIST
END
NO
108
IS THE VOLUME TO ACCESS IN THE LIST ?
NO
109
DENY ACCESS TO THE VOLUME
END
YES
A
A
PRIVATE VOLUME ?
110
YES
NO
ACCESS LOCKING INFORMATION
112
113
ACCESS PERMITTED ?
YES
NO
114
DENY ACCESS TO THE VOLUME
111
ACCESS THE VOLUME

*Fig. 11*

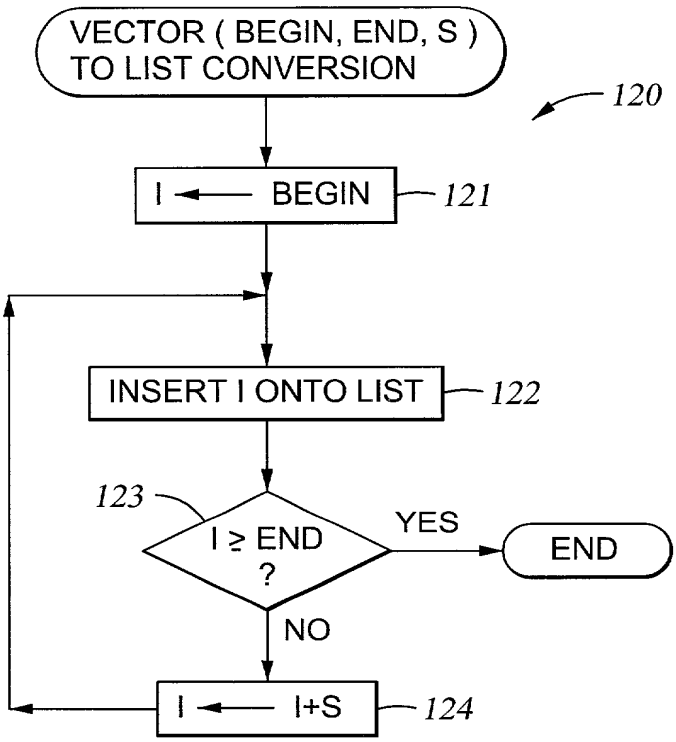
VECTOR ( BEGIN, END, S )
TO LIST CONVERSION
120
I ← BEGIN
121
INSERT I ONTO LIST
122
123
I ≥ END
?
YES
END
NO
I ← I+S
124

*Fig. 12*

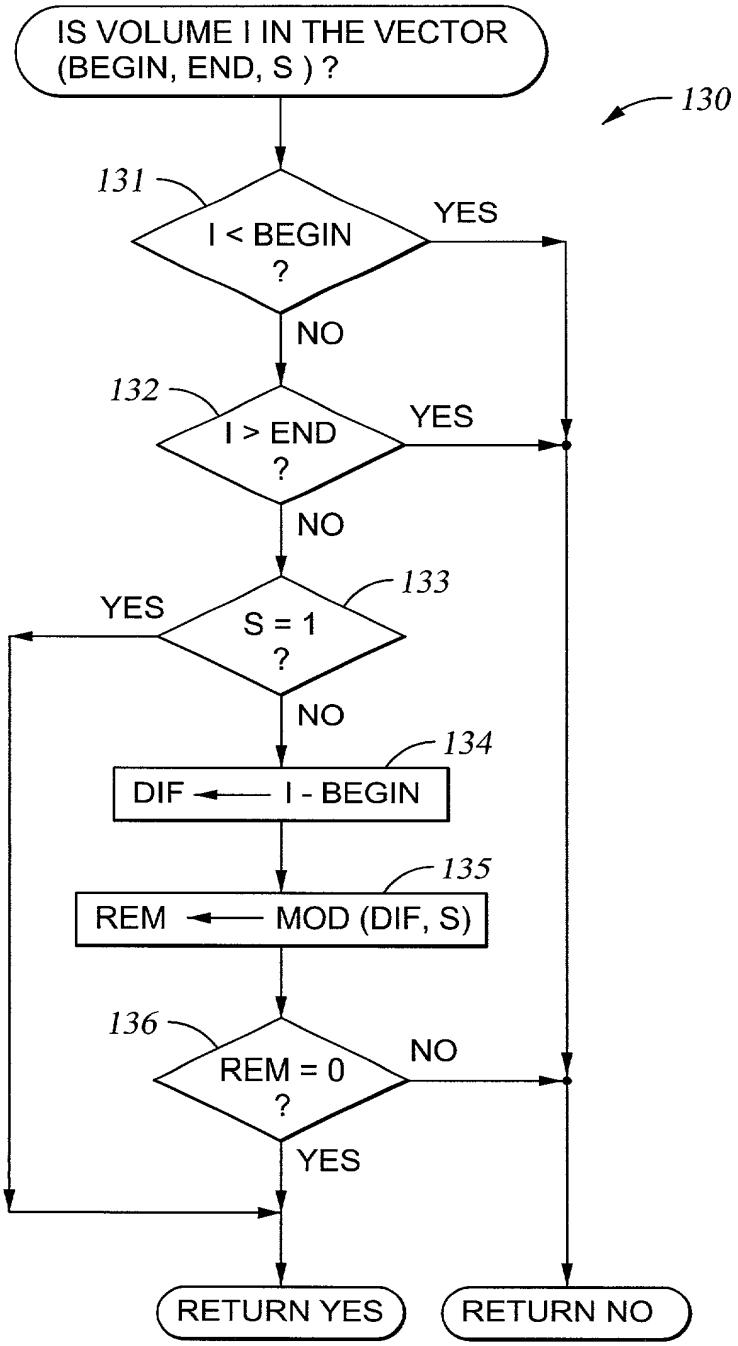
IS VOLUME I IN THE VECTOR (BEGIN, END, S ) ?
130
131
I < BEGIN ?
YES
NO
132
I > END ?
YES
NO
133
S = 1 ?
YES
NO
134
DIF ← I - BEGIN
135
REM ← MOD (DIF, S)
136
REM = 0 ?
NO
YES
RETURN YES
RETURN NO

*Fig. 13*

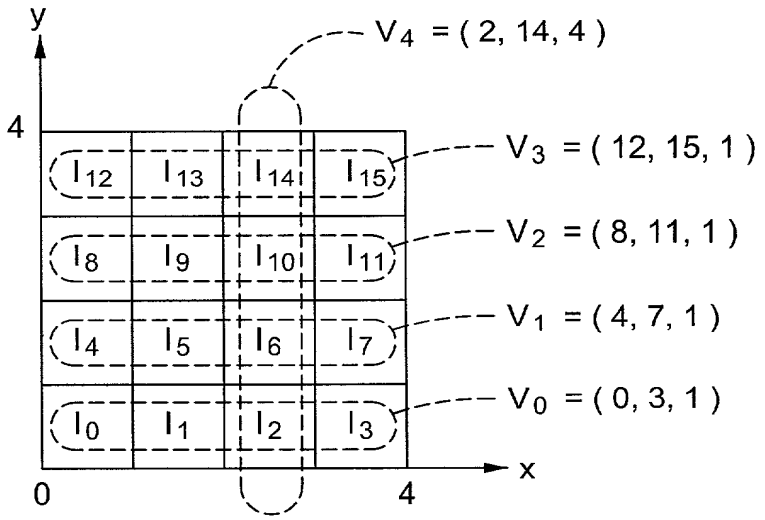
y
4
0
4
x
V4 = ( 2, 14, 4 )
V3 = ( 12, 15, 1 )
V2 = ( 8, 11, 1 )
V1 = ( 4, 7, 1 )
V0 = ( 0, 3, 1 )
I12 I13 I14 I15
I8 I9 I10 I11
I4 I5 I6 I7
I0 I1 I2 I3

*Fig. 14*

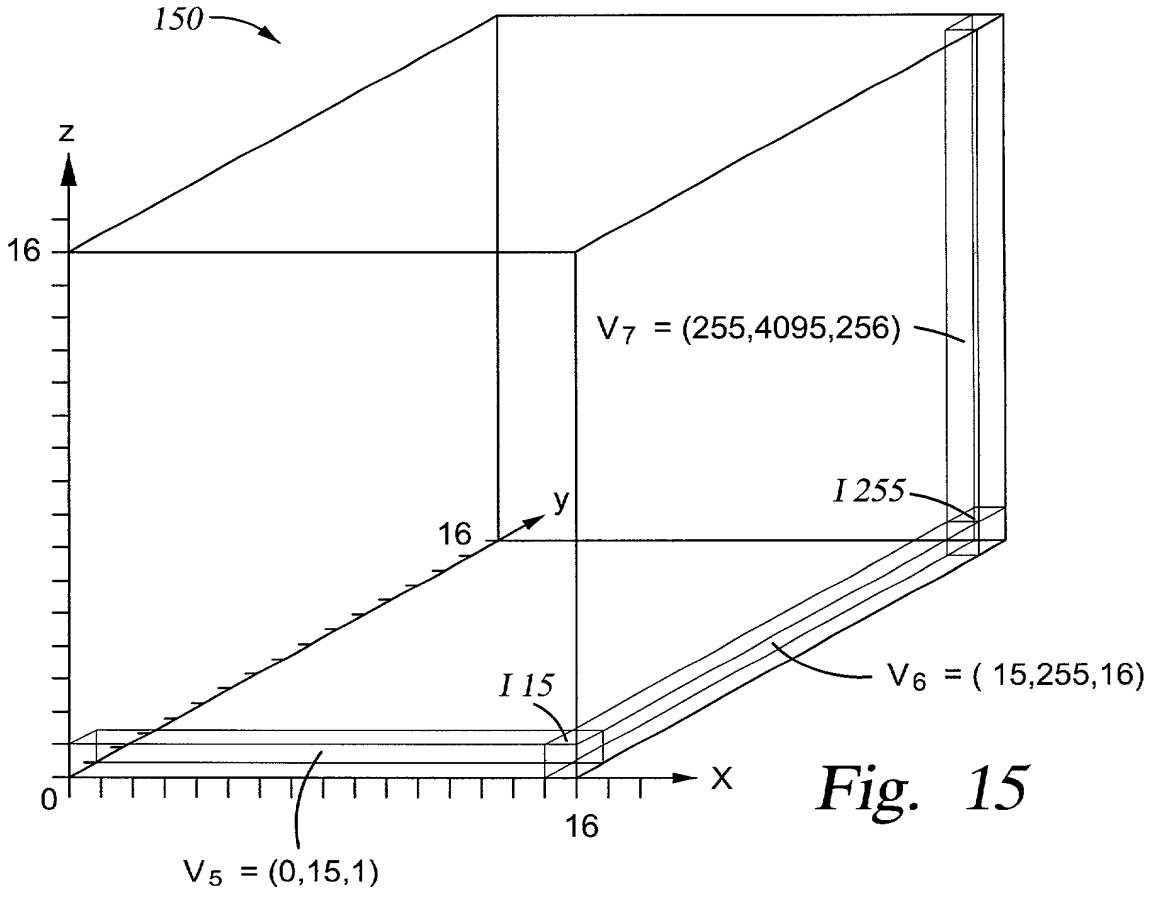
150
z
16
V7 = (255,4095,256)
I 255
y
16
I 15
V6 = ( 15,255,16)
0
x
16
V5 = (0,15,1)

*Fig. 15*

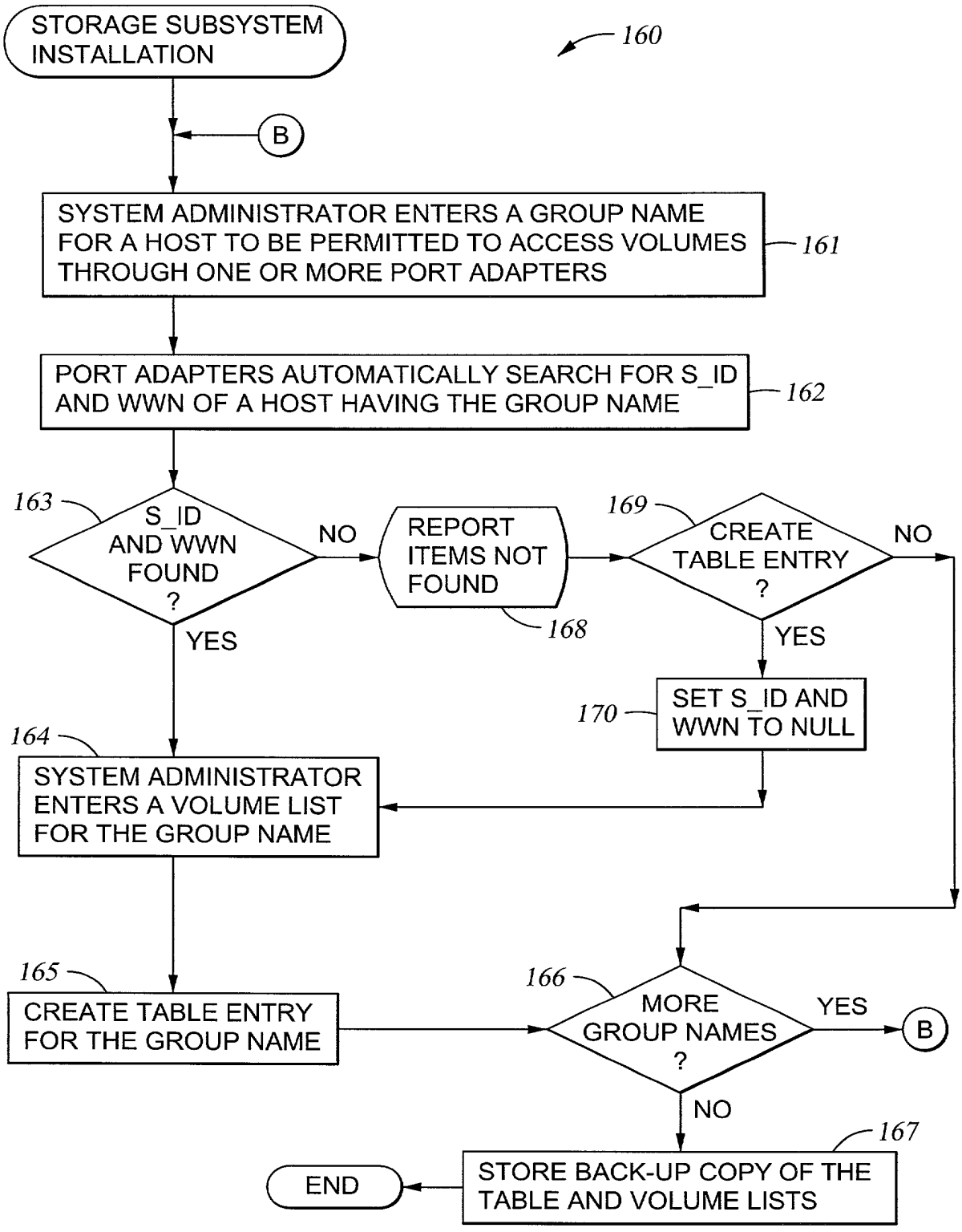
STORAGE SUBSYSTEM INSTALLATION
160
B
SYSTEM ADMINISTRATOR ENTERS A GROUP NAME FOR A HOST TO BE PERMITTED TO ACCESS VOLUMES THROUGH ONE OR MORE PORT ADAPTERS
161
PORT ADAPTERS AUTOMATICALLY SEARCH FOR S_ID AND WWN OF A HOST HAVING THE GROUP NAME
162
163
S_ID AND WWN FOUND ?
NO
REPORT ITEMS NOT FOUND
168
169
CREATE TABLE ENTRY ?
NO
YES
YES
170
SET S_ID AND WWN TO NULL
164
SYSTEM ADMINISTRATOR ENTERS A VOLUME LIST FOR THE GROUP NAME
165
CREATE TABLE ENTRY FOR THE GROUP NAME
166
MORE GROUP NAMES ?
YES
B
NO
167
STORE BACK-UP COPY OF THE TABLE AND VOLUME LISTS
END

*Fig. 16*

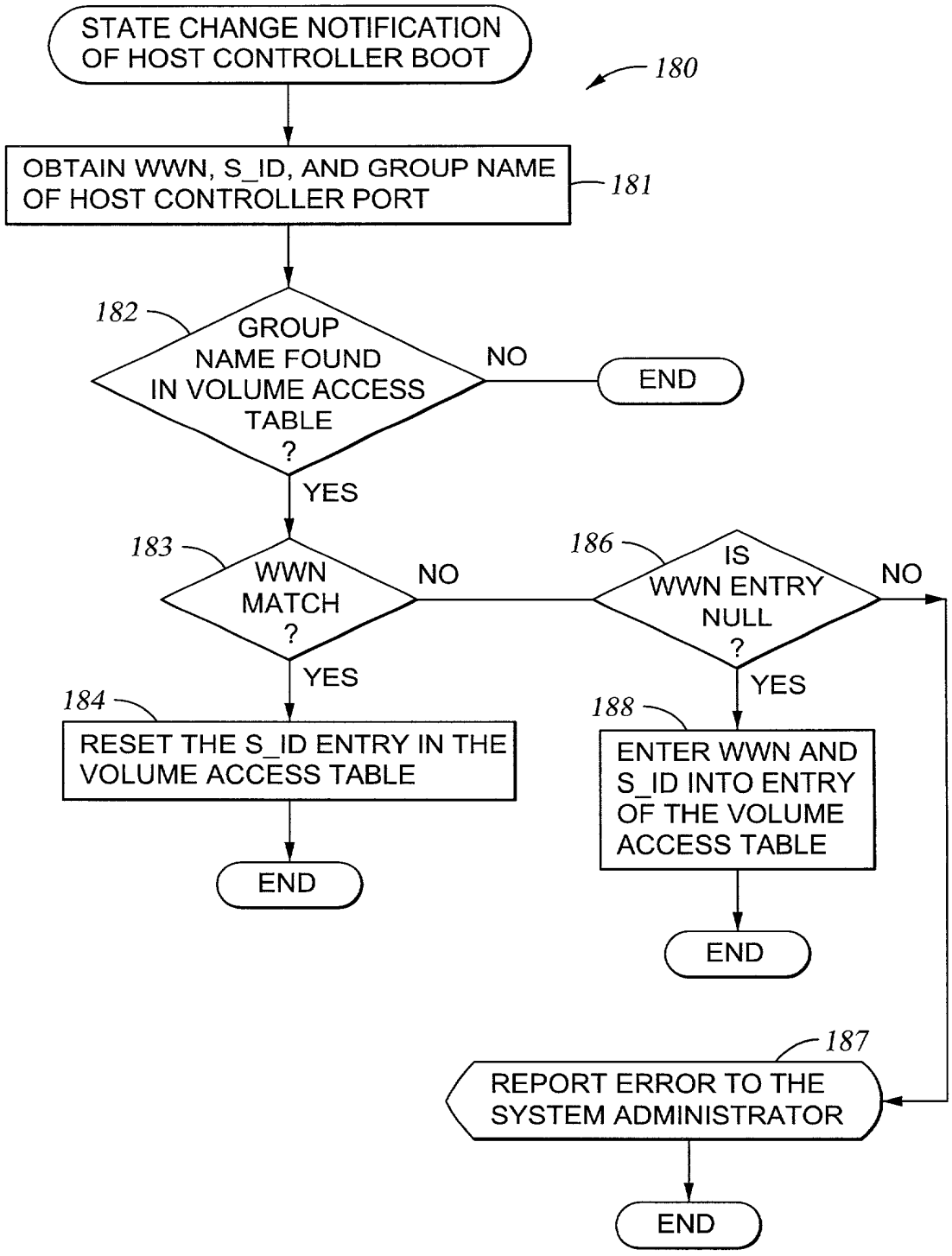
STATE CHANGE NOTIFICATION OF HOST CONTROLLER BOOT
180
OBTAIN WWN, S_ID, AND GROUP NAME OF HOST CONTROLLER PORT
181
182
GROUP NAME FOUND IN VOLUME ACCESS TABLE ?
NO
END
YES
183
WWN MATCH ?
NO
186
IS WWN ENTRY NULL ?
NO
YES
YES
184
RESET THE S_ID ENTRY IN THE VOLUME ACCESS TABLE
END
188
ENTER WWN AND S_ID INTO ENTRY OF THE VOLUME ACCESS TABLE
END
187
REPORT ERROR TO THE SYSTEM ADMINISTRATOR
END

*Fig. 17*

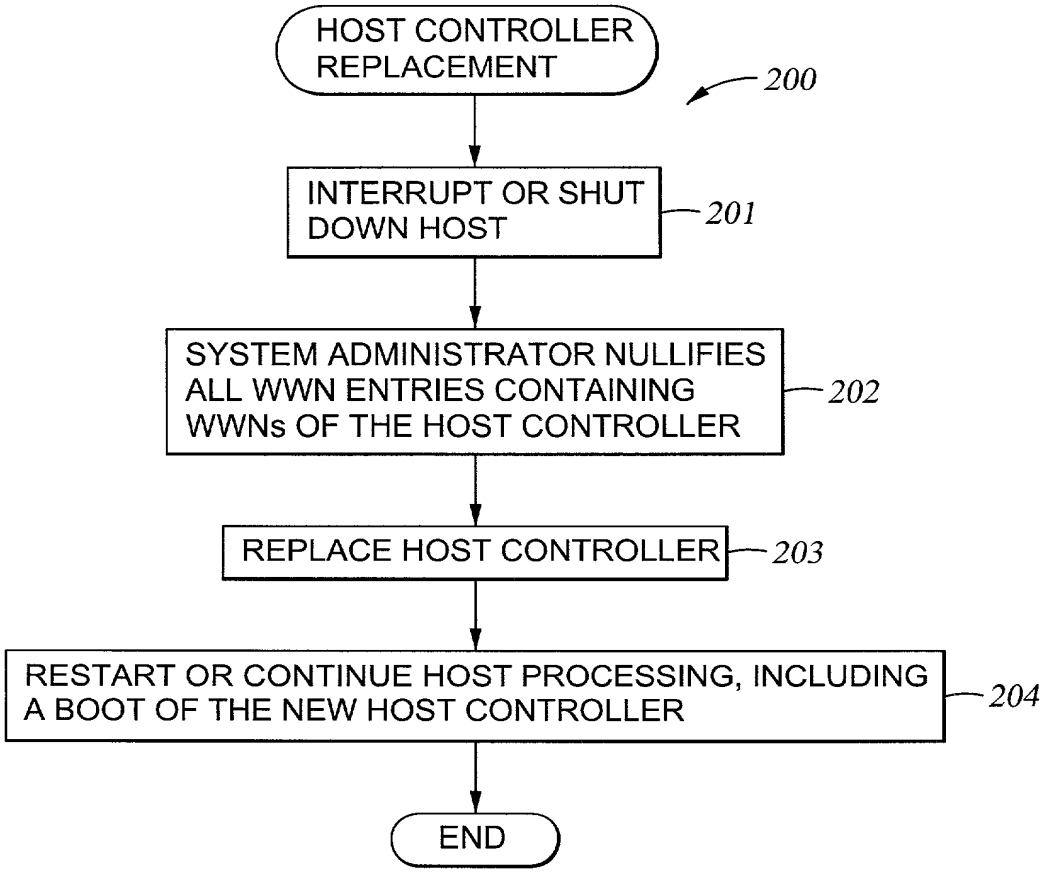
HOST CONTROLLER REPLACEMENT
200
INTERRUPT OR SHUT DOWN HOST
201
SYSTEM ADMINISTRATOR NULLIFIES ALL WWN ENTRIES CONTAINING WWNs OF THE HOST CONTROLLER
202
REPLACE HOST CONTROLLER
203
RESTART OR CONTINUE HOST PROCESSING, INCLUDING A BOOT OF THE NEW HOST CONTROLLER
204
END

*Fig. 18*

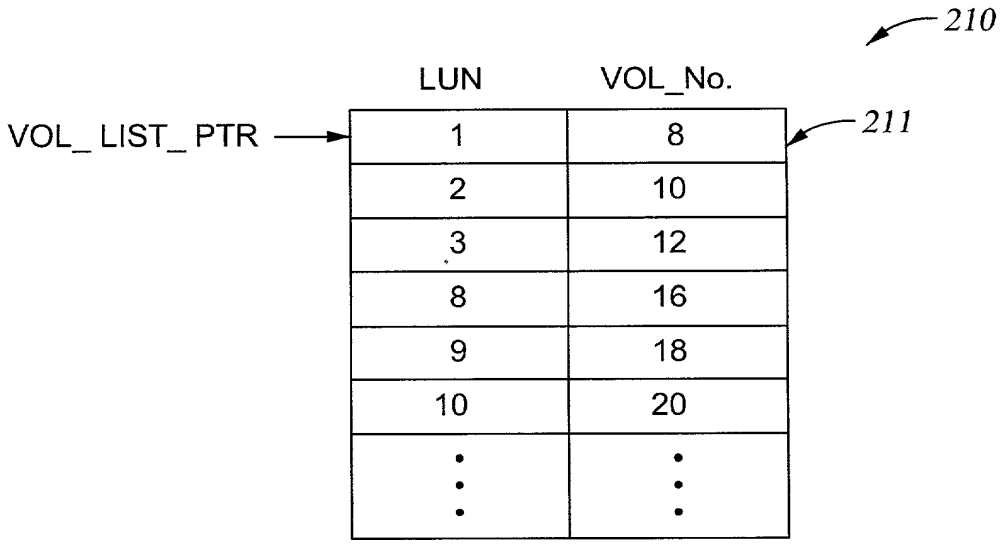
210
LUN
VOL_No.
VOL_ LIST_ PTR
211
1
8
2
10
3
12
8
16
9
18
10
20

*Fig. 19*

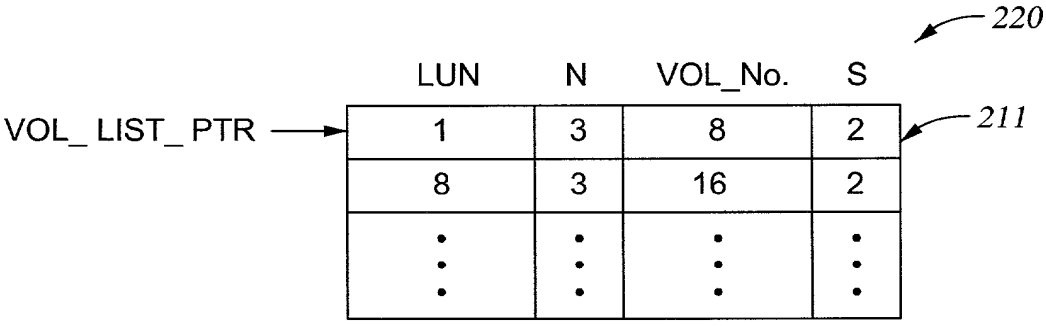
220
LUN
N
VOL_No.
S
VOL_ LIST_ PTR
211
1
3
8
2
8
3
16
2

*Fig. 20*

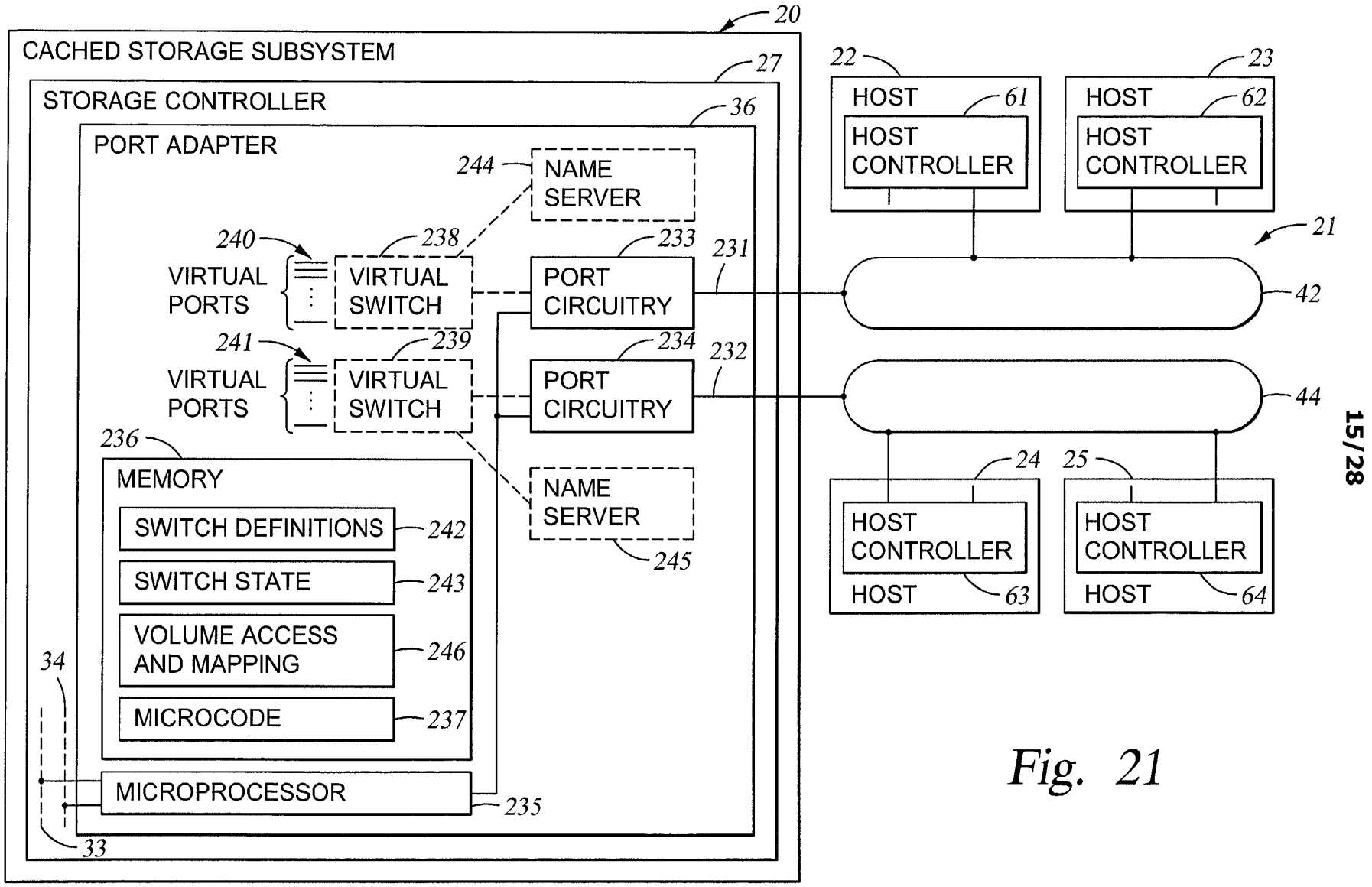
20
CACHED STORAGE SUBSYSTEM
27
STORAGE CONTROLLER
36
PORT ADAPTER
244
NAME SERVER
240
238
VIRTUAL PORTS
VIRTUAL SWITCH
233
PORT CIRCUITRY
231
241
239
VIRTUAL PORTS
VIRTUAL SWITCH
234
PORT CIRCUITRY
232
236
MEMORY
SWITCH DEFINITIONS
242
SWITCH STATE
243
VOLUME ACCESS AND MAPPING
246
MICROCODE
237
NAME SERVER
245
34
MICROPROCESSOR
235
33
22
HOST
61
HOST CONTROLLER
23
HOST
62
HOST CONTROLLER
21
42
44
24
HOST CONTROLLER
HOST
63
25
HOST CONTROLLER
HOST
64

*Fig. 21*

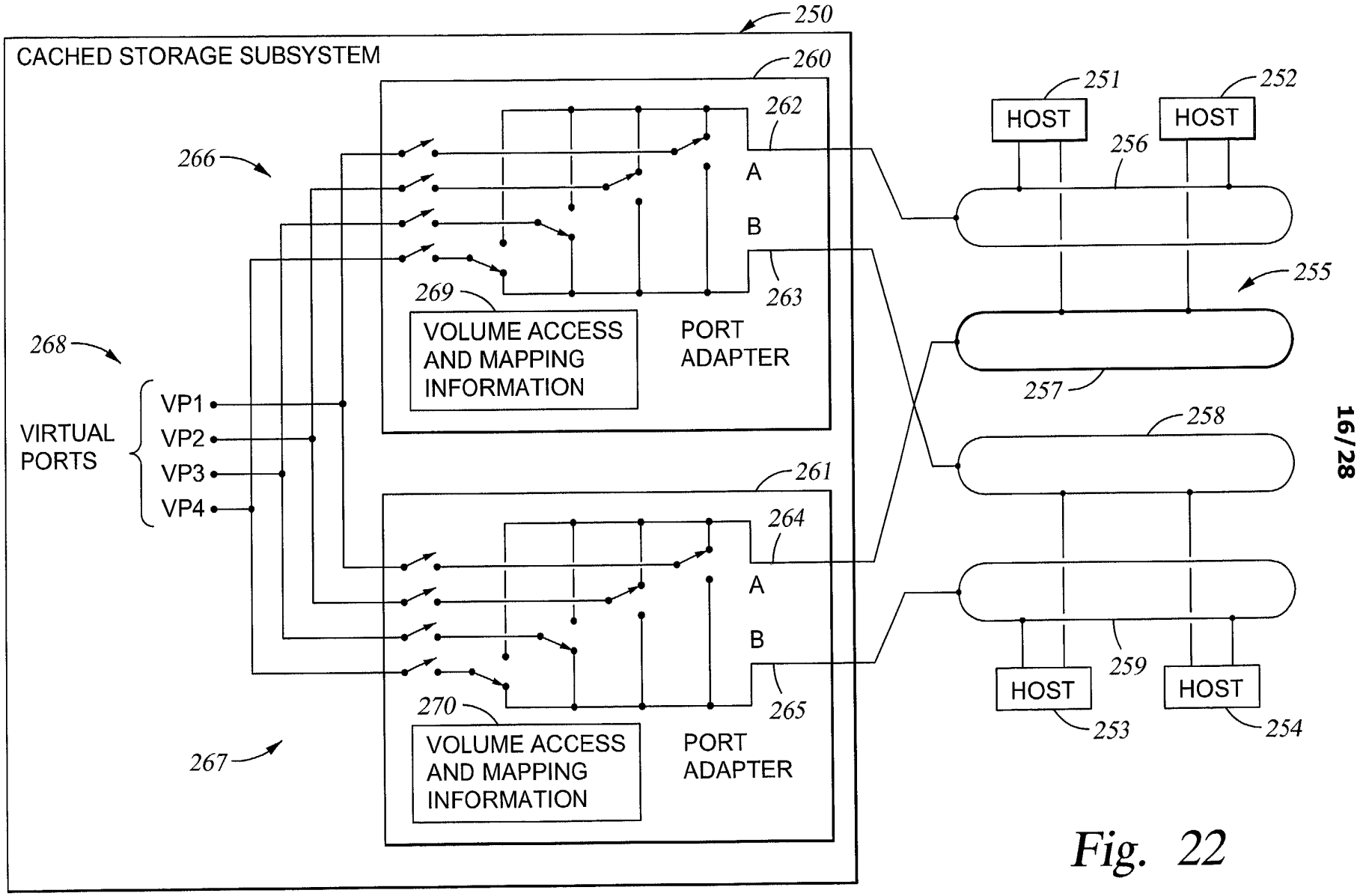
250
CACHED STORAGE SUBSYSTEM
260
262
266
A
B
263
269
VOLUME ACCESS AND MAPPING INFORMATION
PORT ADAPTER
268
VIRTUAL PORTS
VP1
VP2
VP3
VP4
261
264
A
B
265
270
VOLUME ACCESS AND MAPPING INFORMATION
PORT ADAPTER
267
251
HOST
252
HOST
256
255
257
258
259
HOST
253
HOST
254

Fig. 22

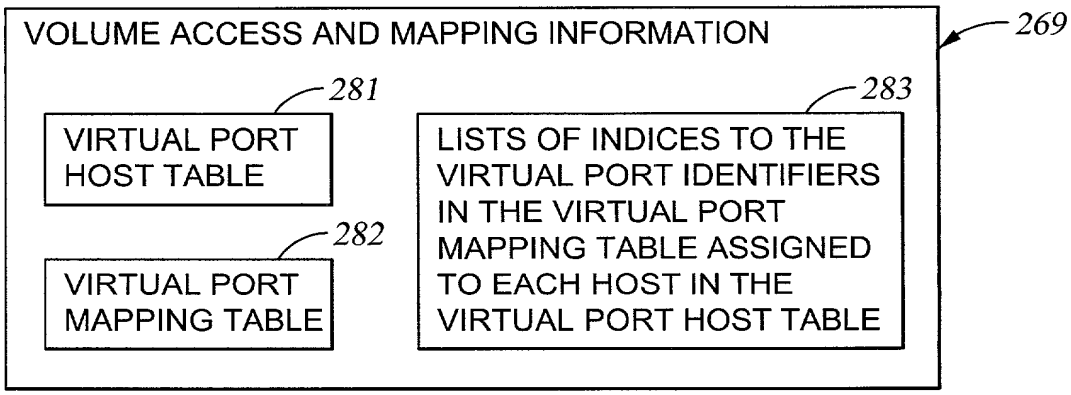


*Fig. 23*

281

| HOST_ID | PORT_A/B | WWN | S_ID | V_PORT INDEX | V_PORT LIST POINTER |
|---|---|---|---|---|---|
| – | – | – | – | – | – |
| – | – | – | – | – | – |
| • | • | • | • | • | • |

*Fig. 24*

282

| V_PORT_ID | HOST INDEX | PRIVATE/ SHARED FLAG | LUN TO LOGICAL VOLUME MAP |
|---|---|---|---|
| – | – | – | – – – – – – |
| – | – | – | – – – – – – |
| • | • | • | |

*Fig. 25*

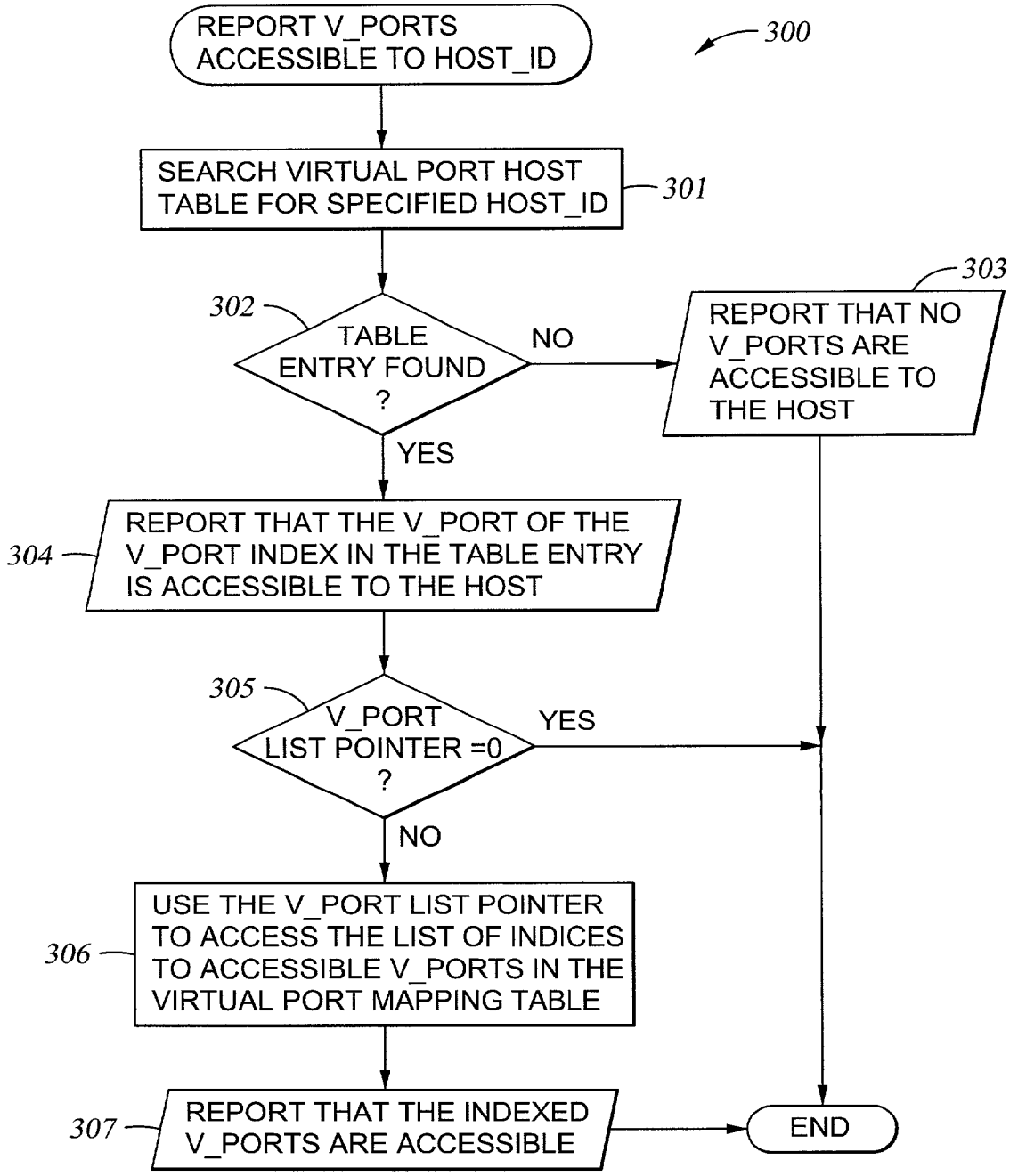
REPORT V_PORTS ACCESSIBLE TO HOST_ID
300
SEARCH VIRTUAL PORT HOST TABLE FOR SPECIFIED HOST_ID
301
302
TABLE ENTRY FOUND ?
NO
303
REPORT THAT NO V_PORTS ARE ACCESSIBLE TO THE HOST
YES
304
REPORT THAT THE V_PORT OF THE V_PORT INDEX IN THE TABLE ENTRY IS ACCESSIBLE TO THE HOST
305
V_PORT LIST POINTER =0 ?
YES
NO
306
USE THE V_PORT LIST POINTER TO ACCESS THE LIST OF INDICES TO ACCESSIBLE V_PORTS IN THE VIRTUAL PORT MAPPING TABLE
307
REPORT THAT THE INDEXED V_PORTS ARE ACCESSIBLE
END

*Fig. 26*

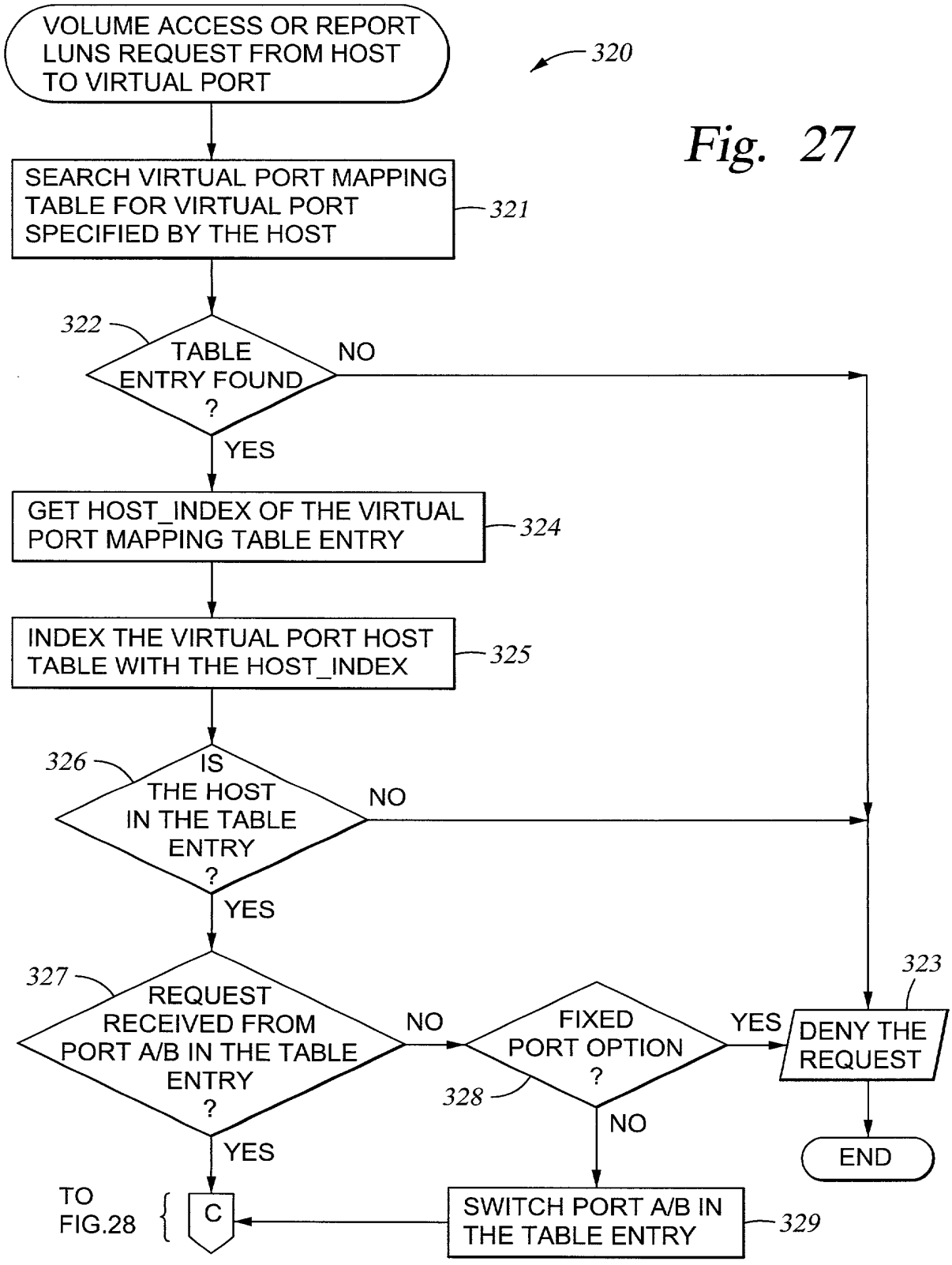
VOLUME ACCESS OR REPORT LUNS REQUEST FROM HOST TO VIRTUAL PORT
320
SEARCH VIRTUAL PORT MAPPING TABLE FOR VIRTUAL PORT SPECIFIED BY THE HOST
321
322
TABLE ENTRY FOUND ?
NO
YES
GET HOST_INDEX OF THE VIRTUAL PORT MAPPING TABLE ENTRY
324
INDEX THE VIRTUAL PORT HOST TABLE WITH THE HOST_INDEX
325
326
IS THE HOST IN THE TABLE ENTRY ?
NO
YES
327
REQUEST RECEIVED FROM PORT A/B IN THE TABLE ENTRY ?
NO
FIXED PORT OPTION ?
YES
328
323
DENY THE REQUEST
END
NO
YES
TO FIG.28
C
SWITCH PORT A/B IN THE TABLE ENTRY
329

Fig. 27

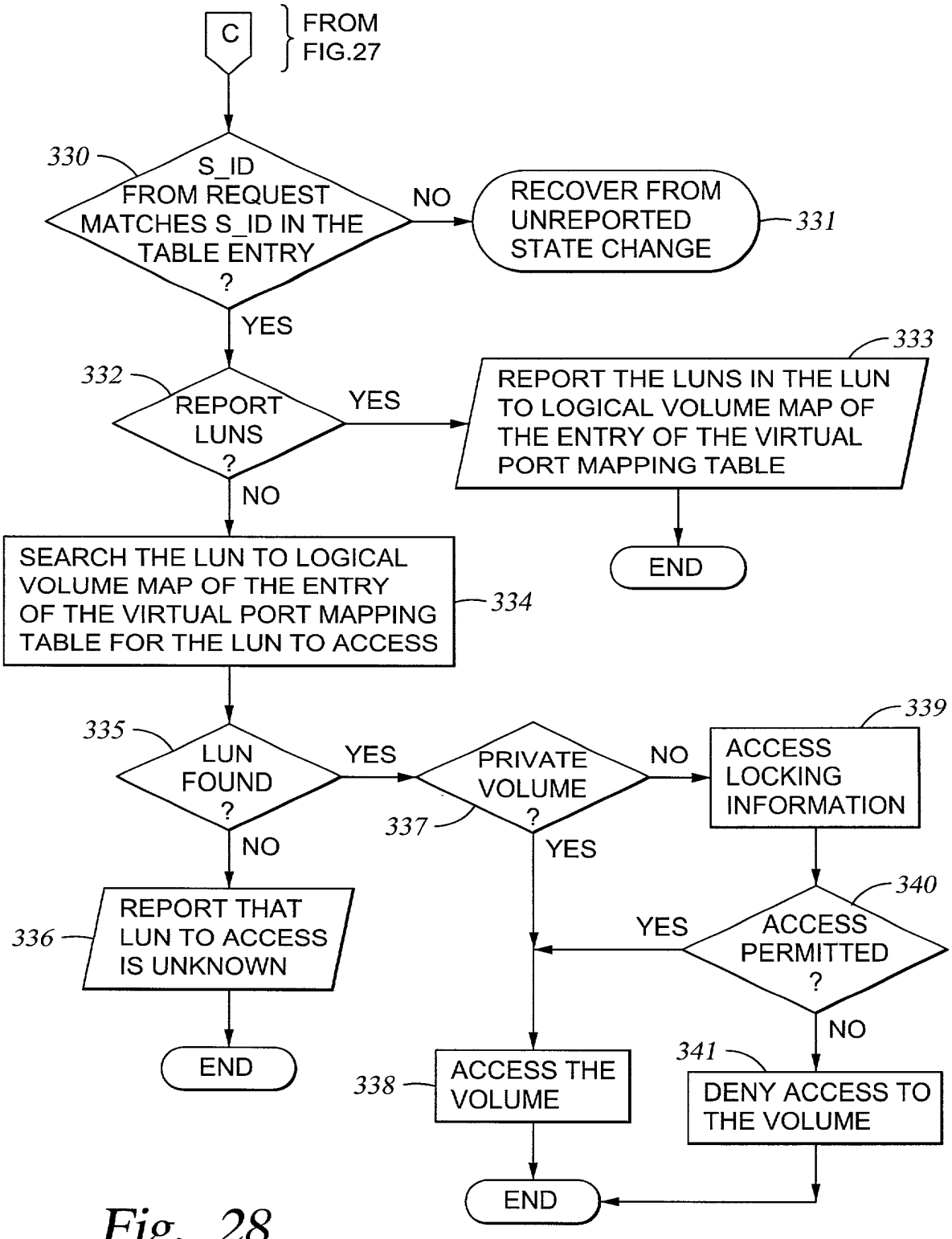
C
FROM FIG.27
330
S_ID FROM REQUEST MATCHES S_ID IN THE TABLE ENTRY ?
NO
RECOVER FROM UNREPORTED STATE CHANGE
331
YES
332
REPORT LUNS ?
YES
333
REPORT THE LUNS IN THE LUN TO LOGICAL VOLUME MAP OF THE ENTRY OF THE VIRTUAL PORT MAPPING TABLE
END
NO
SEARCH THE LUN TO LOGICAL VOLUME MAP OF THE ENTRY OF THE VIRTUAL PORT MAPPING TABLE FOR THE LUN TO ACCESS
334
335
LUN FOUND ?
YES
PRIVATE VOLUME ?
337
NO
339
ACCESS LOCKING INFORMATION
NO
YES
340
ACCESS PERMITTED ?
YES
336
REPORT THAT LUN TO ACCESS IS UNKNOWN
END
NO
341
DENY ACCESS TO THE VOLUME
338
ACCESS THE VOLUME
END

*Fig. 28*

STORAGE SUBSYSTEM 1
ADAPTER PORT 1A

VIRTUAL PORT 1

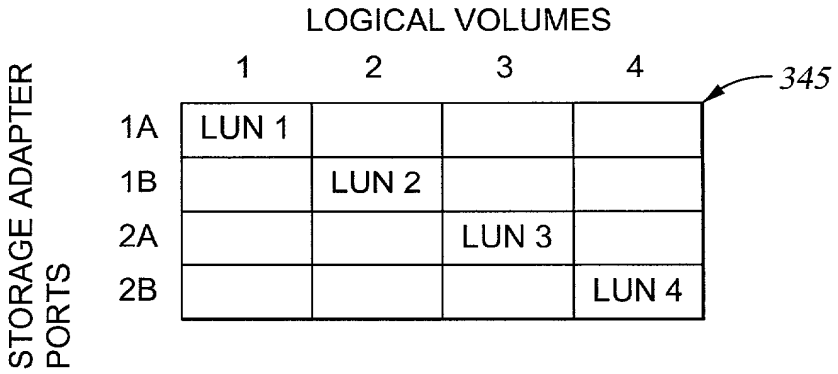


*Fig. 29*

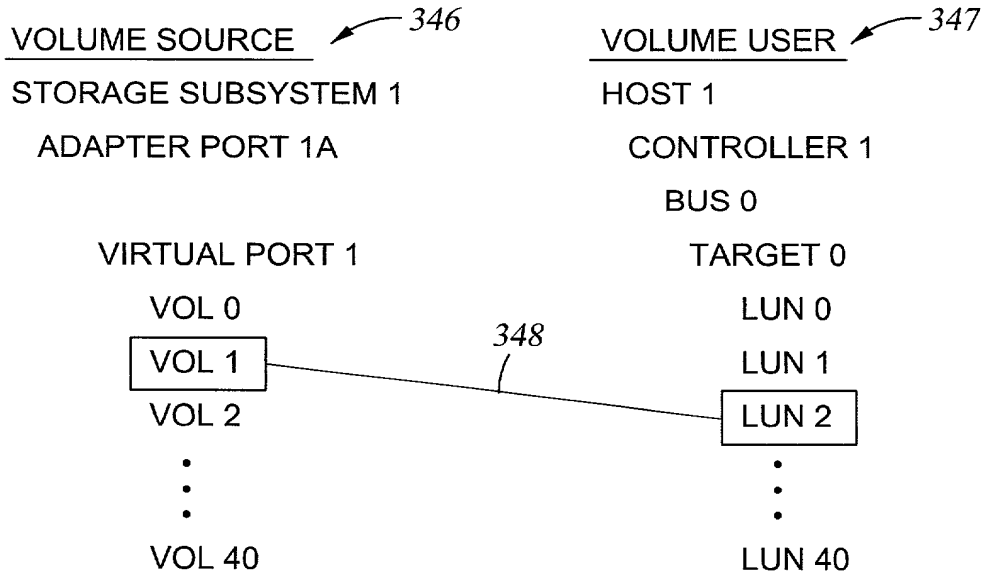


*Fig. 30*

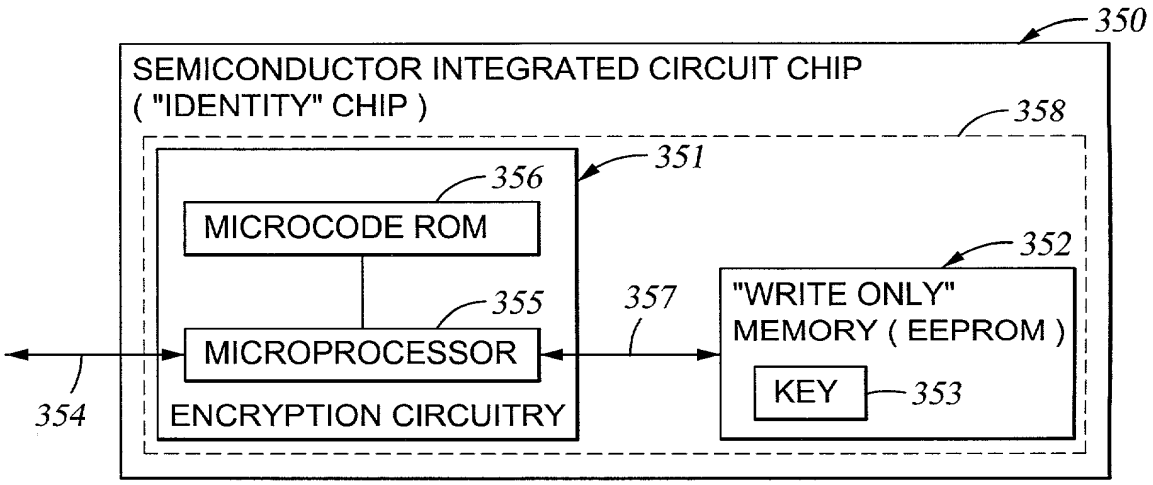
350
SEMICONDUCTOR INTEGRATED CIRCUIT CHIP
( "IDENTITY" CHIP )
358
351
356
MICROCODE ROM
352
"WRITE ONLY"
MEMORY ( EEPROM )
355
357
MICROPROCESSOR
KEY
353
354
ENCRYPTION CIRCUITRY

*Fig. 31*

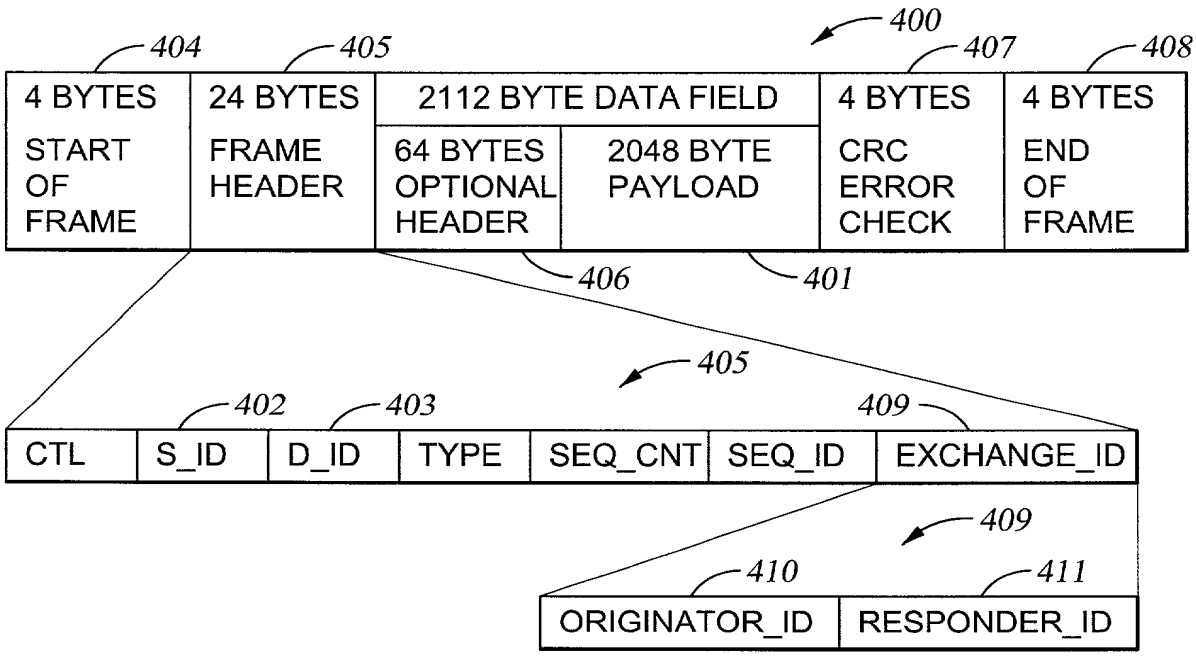
400
404
405
407
408
4 BYTES
START OF FRAME
24 BYTES
FRAME HEADER
2112 BYTE DATA FIELD
64 BYTES OPTIONAL HEADER
2048 BYTE PAYLOAD
4 BYTES
CRC ERROR CHECK
4 BYTES
END OF FRAME
406
401
405
402
403
409
CTL
S_ID
D_ID
TYPE
SEQ_CNT
SEQ_ID
EXCHANGE_ID
409
410
411
ORIGINATOR_ID
RESPONDER_ID

*Fig. 34*

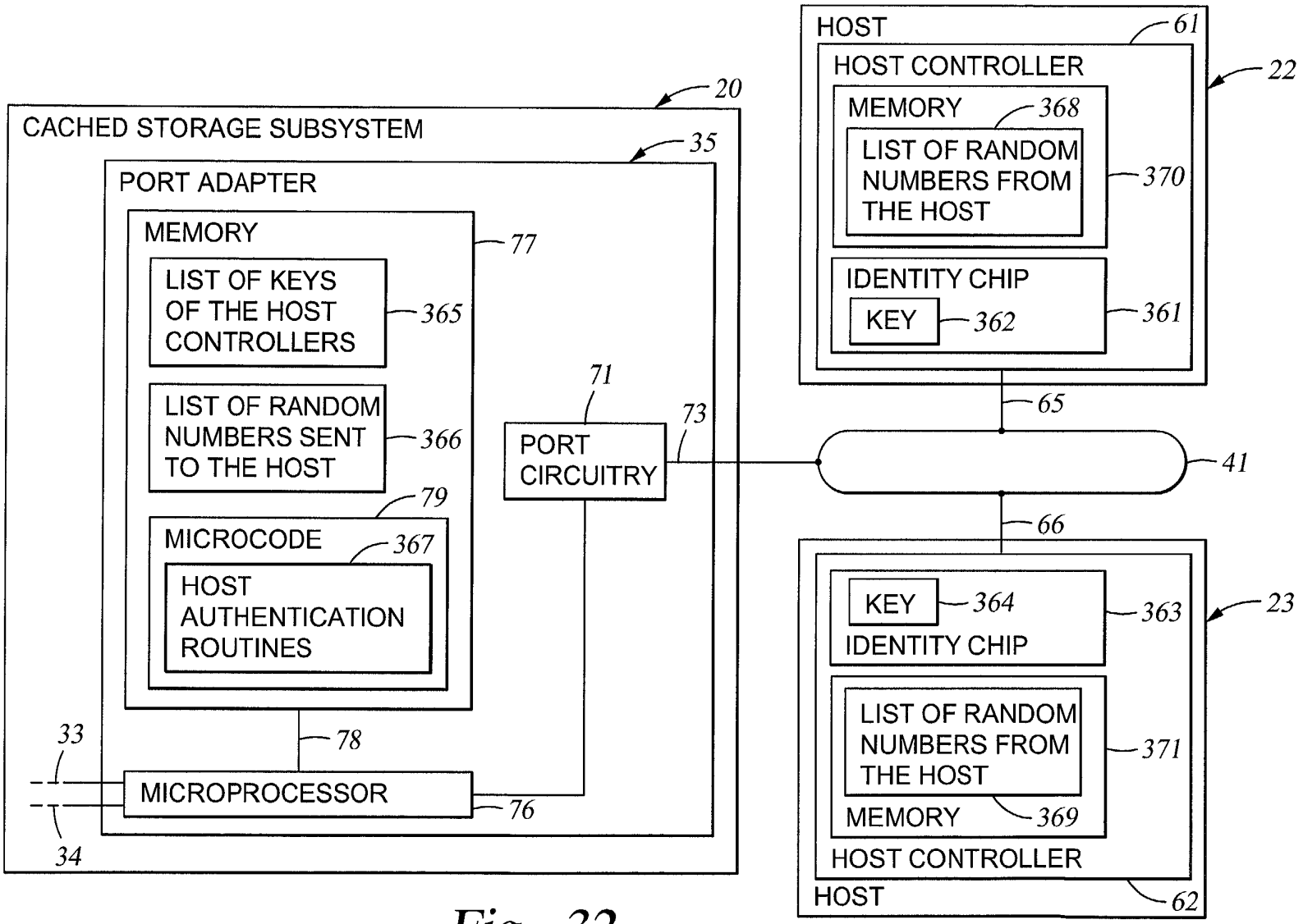
HOST
61
HOST CONTROLLER
22
MEMORY
368
LIST OF RANDOM NUMBERS FROM THE HOST
370
IDENTITY CHIP
KEY
362
361
65
41
66
20
CACHED STORAGE SUBSYSTEM
35
PORT ADAPTER
MEMORY
77
LIST OF KEYS OF THE HOST CONTROLLERS
365
LIST OF RANDOM NUMBERS SENT TO THE HOST
366
71
73
PORT CIRCUITRY
79
MICROCODE
367
HOST AUTHENTICATION ROUTINES
78
33
MICROPROCESSOR
76
34
KEY
364
363
IDENTITY CHIP
23
LIST OF RANDOM NUMBERS FROM THE HOST
371
MEMORY
369
HOST CONTROLLER
HOST
62

*Fig. 32*

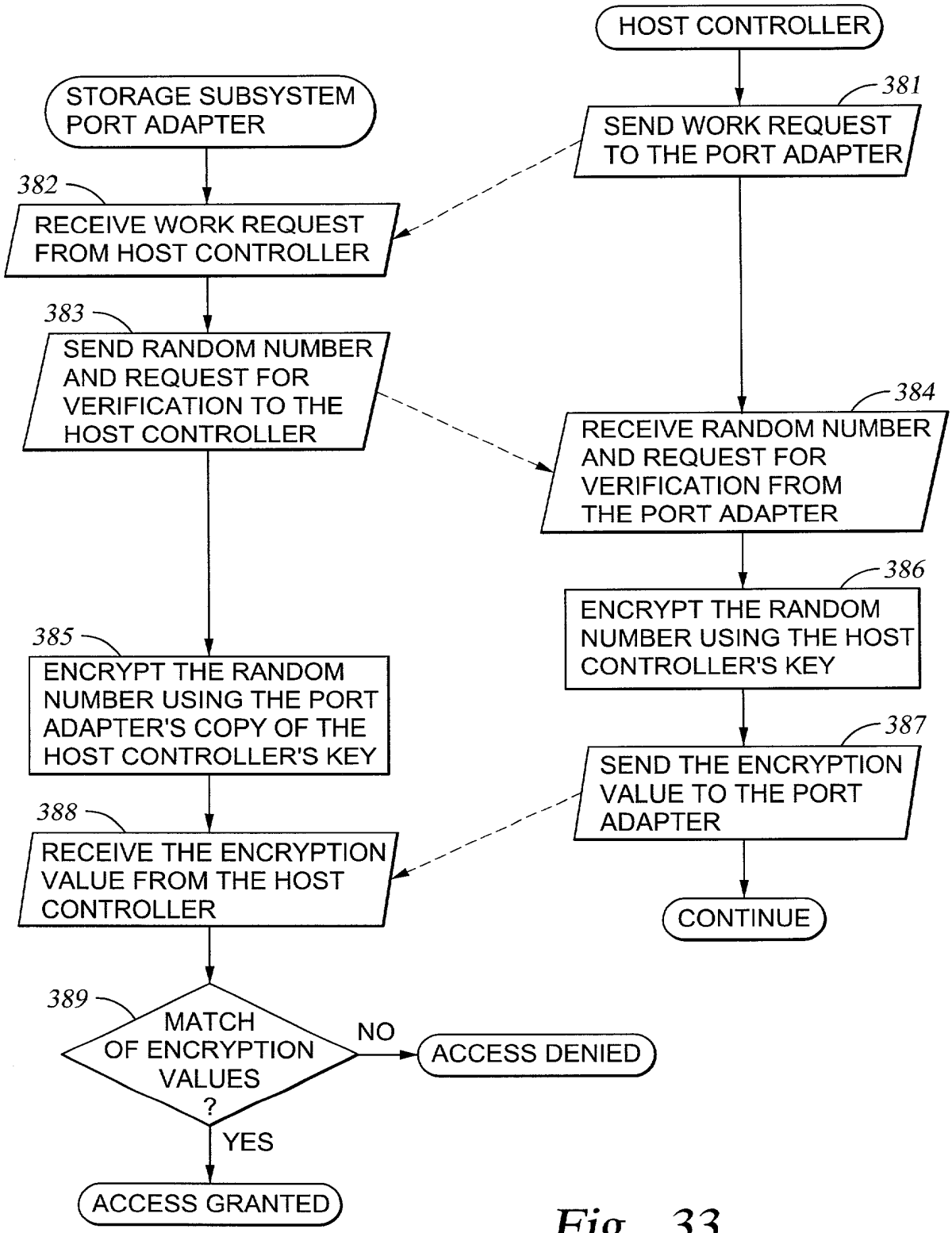
HOST CONTROLLER
381
SEND WORK REQUEST TO THE PORT ADAPTER
STORAGE SUBSYSTEM PORT ADAPTER
382
RECEIVE WORK REQUEST FROM HOST CONTROLLER
383
SEND RANDOM NUMBER AND REQUEST FOR VERIFICATION TO THE HOST CONTROLLER
384
RECEIVE RANDOM NUMBER AND REQUEST FOR VERIFICATION FROM THE PORT ADAPTER
386
ENCRYPT THE RANDOM NUMBER USING THE HOST CONTROLLER'S KEY
385
ENCRYPT THE RANDOM NUMBER USING THE PORT ADAPTER'S COPY OF THE HOST CONTROLLER'S KEY
387
SEND THE ENCRYPTION VALUE TO THE PORT ADAPTER
388
RECEIVE THE ENCRYPTION VALUE FROM THE HOST CONTROLLER
CONTINUE
389
MATCH OF ENCRYPTION VALUES ?
NO
ACCESS DENIED
YES
ACCESS GRANTED

*Fig. 33*

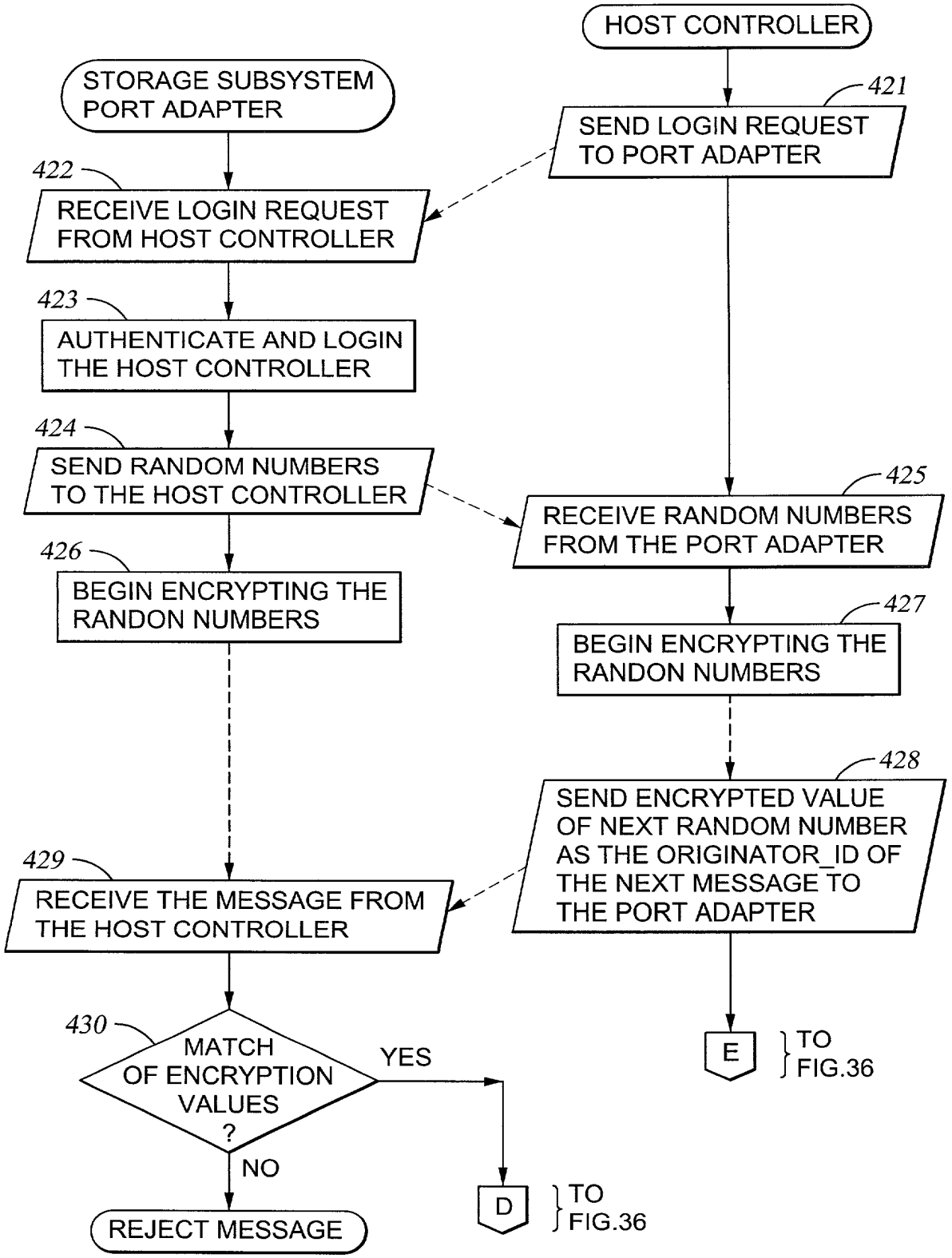
HOST CONTROLLER
STORAGE SUBSYSTEM PORT ADAPTER
421
SEND LOGIN REQUEST TO PORT ADAPTER
422
RECEIVE LOGIN REQUEST FROM HOST CONTROLLER
423
AUTHENTICATE AND LOGIN THE HOST CONTROLLER
424
SEND RANDOM NUMBERS TO THE HOST CONTROLLER
425
RECEIVE RANDOM NUMBERS FROM THE PORT ADAPTER
426
BEGIN ENCRYPTING THE RANDON NUMBERS
427
BEGIN ENCRYPTING THE RANDON NUMBERS
428
SEND ENCRYPTED VALUE OF NEXT RANDOM NUMBER AS THE ORIGINATOR_ID OF THE NEXT MESSAGE TO THE PORT ADAPTER
429
RECEIVE THE MESSAGE FROM THE HOST CONTROLLER
430
MATCH OF ENCRYPTION VALUES ?
YES
NO
REJECT MESSAGE
D
TO FIG.36
E
TO FIG.36

*Fig. 35*

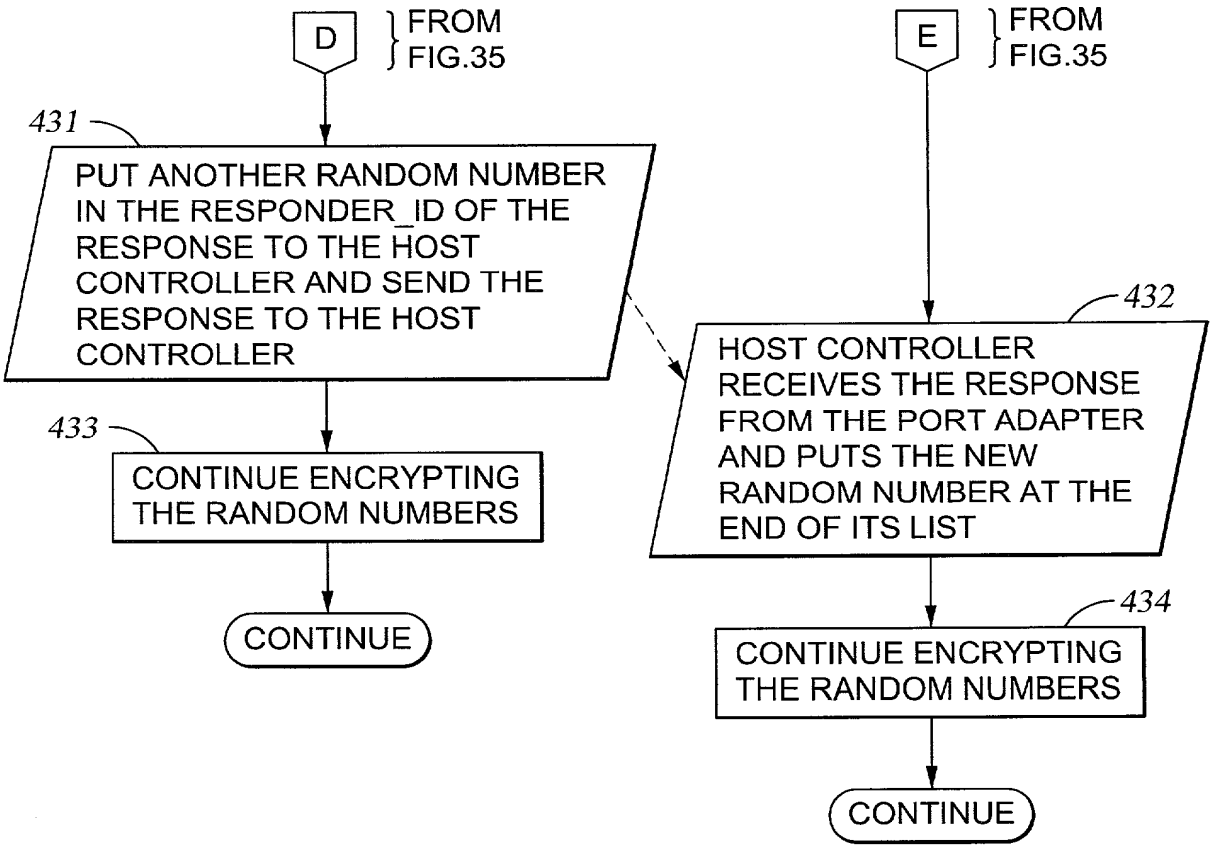
D
FROM FIG.35
E
FROM FIG.35
431
PUT ANOTHER RANDOM NUMBER IN THE RESPONDER_ID OF THE RESPONSE TO THE HOST CONTROLLER AND SEND THE RESPONSE TO THE HOST CONTROLLER
432
HOST CONTROLLER RECEIVES THE RESPONSE FROM THE PORT ADAPTER AND PUTS THE NEW RANDOM NUMBER AT THE END OF ITS LIST
433
CONTINUE ENCRYPTING THE RANDOM NUMBERS
434
CONTINUE ENCRYPTING THE RANDOM NUMBERS
CONTINUE
CONTINUE

*Fig. 36*

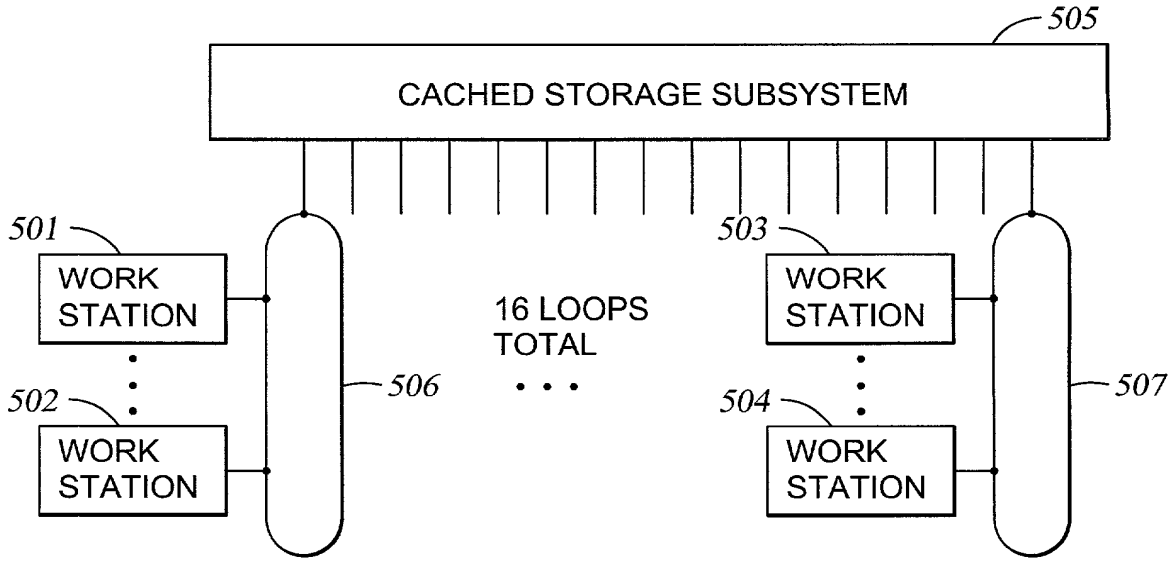
505
CACHED STORAGE SUBSYSTEM
501
WORK STATION
502
WORK STATION
506
16 LOOPS TOTAL
503
WORK STATION
504
WORK STATION
507

*Fig. 37*

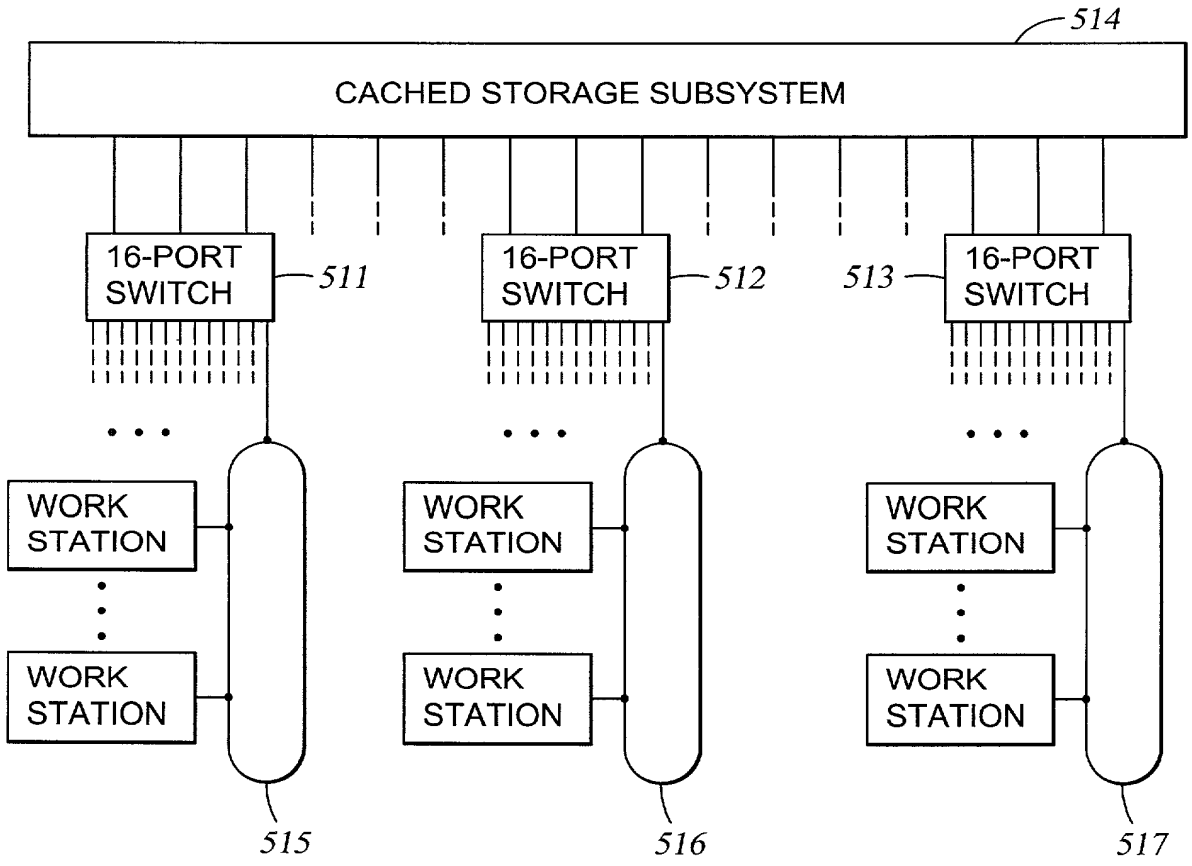
514
CACHED STORAGE SUBSYSTEM
16-PORT SWITCH
511
16-PORT SWITCH
512
513
16-PORT SWITCH
WORK STATION
WORK STATION
WORK STATION
WORK STATION
WORK STATION
WORK STATION
515
516
517

*Fig. 38*

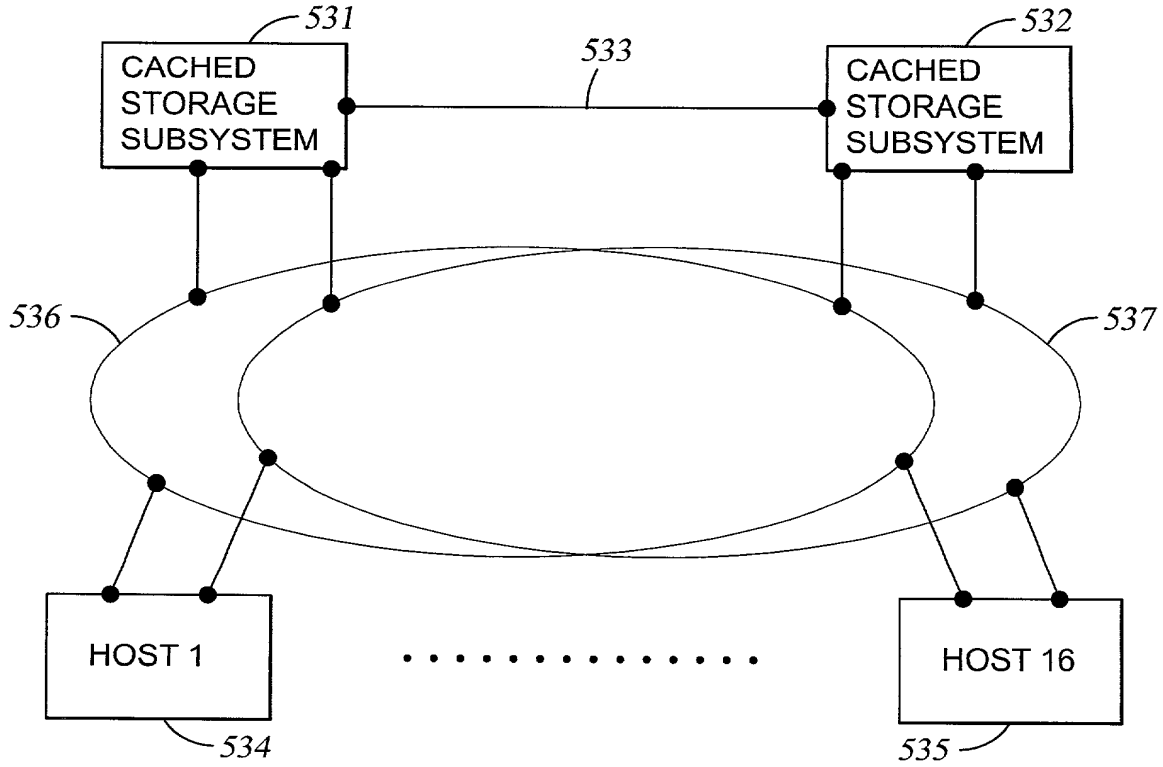
531
CACHED STORAGE SUBSYSTEM
533
532
CACHED STORAGE SUBSYSTEM
536
537
HOST 1
HOST 16
534
535

Fig. 39

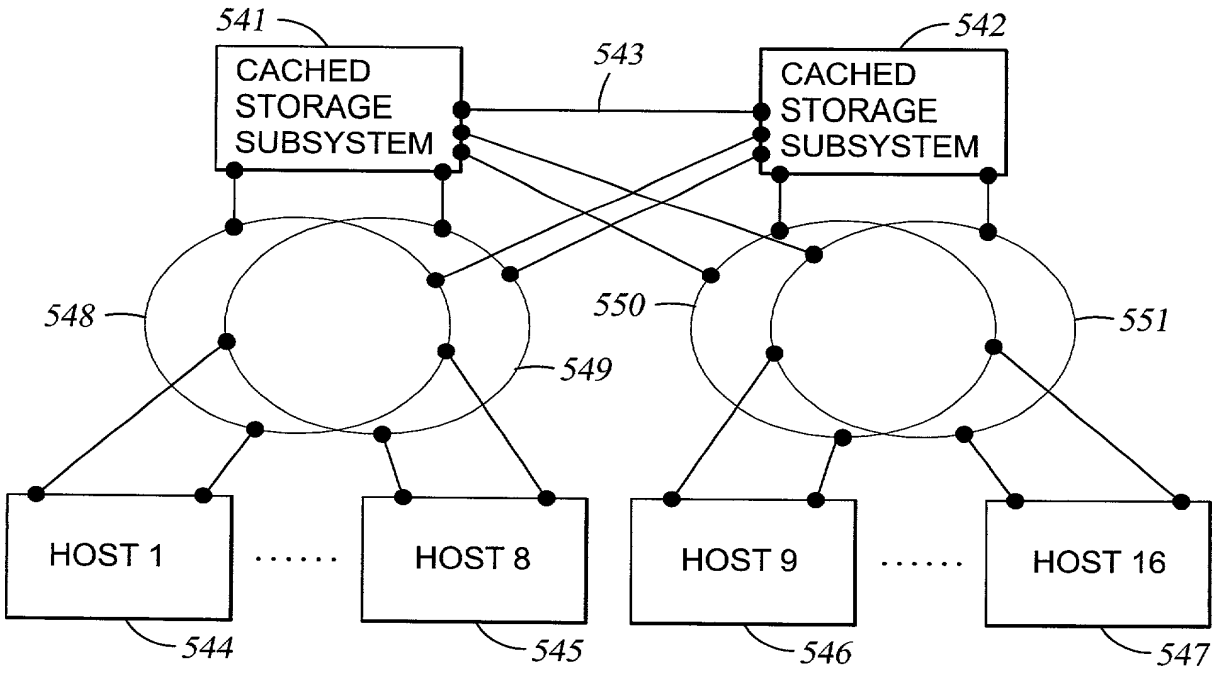
541
CACHED STORAGE SUBSYSTEM
543
542
CACHED STORAGE SUBSYSTEM
548
549
550
551
HOST 1
HOST 8
HOST 9
HOST 16
544
545
546
547

Fig. 40